# SCIENCE

VOL. LXXII FRIDAY, SEPTEMBER 5, 1930 No. 1862

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SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal

Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

## SIZE AND FORM IN PLANTS[1]

By Dr. F. O. BOWER

PROFESSOR EMERITUS OF BOTANY, UNIVERSITY OF GLASGOW

Two years have passed since the association last met in Britain. Events have happened in that interval which mark the close of the Darwinian Epoch. Down House, in which Darwin lived and worked, has been bought, restored and endowed by Mr. Buckston Browne and presented by him to the association, who hold it in custody for the nation. The house is now open as a shrine to those who treasure Darwin's memory. They may enter the study where the "Origin of Species" was penned, or wander out to the Sand Walk, and draw such inspiration as those spots may yet afford to those who are face to face with problems cognate to his own. These years have also severed personal links with Darwin himself. Sir William Thiselton-Dyer, who died in December, 1928, had been his frequent correspondent. It was he who, more than any other, carried the evolutionary stimulus forward into the botanical schools of Britain. Sir Edwin Ray Lankester, whose portrait by Orpen was a poignant feature of last year's academy, died in August, 1929. Not only was he the leading zoologist of his time, but he has left a deep impress on general morphology, for he was the first to analyze from the evolutionary aspect the degrees of "sameness" of parts, whether in animals or in plants. These two octogenarians were among the latest links between Darwin himself and living men of science. And so this last meeting of the association before its centenary next year falls at a nodal point in the personal history of evolution.

Morphology, or the study of form, was closely interwoven with the life work of Darwin, and—to

[1] Address of the president of the British Association for the Advancement of Science, Bristol, September 3, 1930.

use his own words—"it is one of the most interesting departments of natural history, and may almost be said to be its very soul." Since the association has seen fit to choose as this year's president a botanist whose work has dealt specially with form in plants, the occasion seems apt for considering certain morphological questions that present themselves in this eighth decade since the "Origin of Species" was published.

The word morphology was applied by Goethe in 1817, in a general sense, to the study of form. Though a pre-Darwinian, he showed rare foresight in insisting that the living form is only momentarily stable, never permanent. But years elapsed before that instability of form of living things, which he clearly saw, became the very focus of evolutionary theory. Even Goethe's prophetic gaze was blurred by the hazy imaginings of idealistic philosophy. The clarifying mind of Schleiden resolved that mist by resort to naked fact. In 1845 he stoutly asserted that the history of development is the true foundation for all insight into living form. This opened the way for a host of workers, who patiently observed and compared the facts of individual development, particularly in plants of low organization. By them the field was prepared for the magic touch of Darwin, and in the enthusiastic words of Sachs, "the theory of descent had only to accept what genetic morphology had actually brought to view."

The effect of that theory should have been to sweep aside all idealistic morphology based on the higher forms, and to rivet attention upon organisms low in the scale. It was the habit of starting comparison from the highest state of organization that was the fundamental error of the idealistic nature philosophers; even now traces of it still persist. An illuminating alternative was presented by that noble passage with which the "Origin of Species" ends. Speaking of his theory, Darwin wrote: "There is a grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms, or into one; and that—from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved." He forecast from the application of his theory that "our classifications will come to be, as far as they can be so made, genealogies; and they will then truly give what may be called the plan of creation."

Whether there was only one original form of life or many is still an open question. Nevertheless, among the welter of organisms rightly held as primitive, the Flagellata may with some degree of reason be named as combining in their motile and sedentary stages respectively the animal and vegetable characters. They suggest a sort of starting-point from which the two kingdoms might have diverged. The probability of their common origin is strong; but the divergence must have been early, each taking its own independent course, with increasing size and complexity of the individual. In tracing this I would ask your special attention this evening to the kingdom of plants.

The first of the laws laid down by Lamarck[2] in his "Histoire Naturelle" as fundamental in the evolution of animals and plants ran thus: "Life by its intrinsic forces tends to increase the volume of every living body, and to enlarge its parts up to a limit which it determines itself." When in unicellular organisms, following this law, a certain size has been reached, fission follows, and the equal halves separate as new individuals. In pluricellular bodies, however, the products of cell-division do not separate, but continue a communal life; and the individual may increase, with further division of its cells, to large size and complexity. We may picture how, based upon the mobile stage of a flagellate, the aggregate might form an animal body with motility as a leading feature; on the other hand, based upon the sedentary stage, an immobile plant-body would result. The animal, adopting a predatory habit and colorless, might progress along lines of dependent nutrition, finding and ingesting food already organized; the sedentary green plant might evolve along lines of physiological independence, constructing its own organic supplies. Whether or not this be a true picture, the whole organization of the two kingdoms diverged on the basis of nutrition. Herbert Spencer contrasted them physiologically, showing how animals are expenders, while plants are accumulators; that the former are limited in their growth by the balance of expenditure against nutrition; in the latter growth is not so limited. Thus the problems that follow on increasing size may be expected to work out differently in view of the animal kingdom comprising organisms of high expenditure and not self-nourishing, while plants are self-nourishing accumulators.

The result of this difference may be illustrated by contrasting some of the highest examples of either kingdom; for instance, the elephant with the trees of the forest through which he roams. On the one hand, the relative fewness of the mobile elephants, their less stature and compact form, their columnar legs needed to support the barrel-like body, the receptacle for ingested food, the economy of external surface and the highly developed internal surfaces. On the other hand, the height, immobility and large number of the trees, with their massive stems and

[2] Lamarck died in 1829, and the association has contributed to a fund being raised for a memorial by the Linnean Society of Northern France.

highly complex shoots and roots, so necessary for acquiring food directly from the air and soil. We may further contrast the genesis of the individual in either case. In the mammal the parts are formed once for all, its embryology being an incident closed early in the individual life; but in the tree embryology may be continued for centuries, and is theoretically unlimited, except by death; during life it has the power of producing leaves and branches from every distal bud. The fact is that, though certain underlying principles are the same for both kingdoms, the working out has been distinct from the first. Hence the morphology of plants must stand on its own feet; indeed it has been said with some degree of truth that whenever botanists have borrowed their morphological outlook from the sister science they have gone wrong.

The normal development of a multicellular plant starts from the fertilized egg, and elaboration both external and internal follows on increasing size. Polarity, that is, the distinction of apex and base, is defined in most plants of high organization by the first cell-cleavage. The apex adopts at once the continued development that is its characteristic. Branching of various types follows in all but the simplest, to constitute the complex shoot, while correlative basal branching gives the root system that fixes the non-motile body in the soil. The scheme of growth and branching thus started is theoretically open to unlimited increase, and the initiation of new parts is in point of number on a geometrical scale. This is suitable enough for organisms able to accumulate material, as plants do; indeed, the elaboration of the vegetative system will enhance its powers of self-nutrition, so far as the parts become functional; but this is never fully realized beyond the earlier steps.

The focus of all such development is the growing point, respectively, of root or shoot. Any one who carefully dissects a suitable bud, peeling off the successively smaller leaves, may finally see with the naked eye or with a simple lens a pearly cone of semi-transparent tissue at the tip of the stem. This is the growing point itself, which possesses theoretically unlimited formative power. It is like a permanent sector of the original embryo that is fed continually from the mature tissues below, and as continually forms fresh tissues at the tip. But as the tip advances, lateral swellings of the surface appear in due order, which are new leaves and buds. Various attempts have been made to link the genesis of these outgrowths of the radial shoot with the outer world as regards their position and number. But we have it as the latest authoritative statement on this point that such a relation does not exist. "This much is proved," says Professor von Goebel, that, "so far as we can see, the question relates to conditions of growth and symmetry that arise in the growing point. . . . All theories as to leaf position that allotted a passive rôle to the growing point were mistaken, however acute the reasoning that was brought to bear thereon."[3] This is von Goebel's summing up for external parts. On the other hand, within the growing point, and often, though not always, related to the external parts, there is a progressive formation of internal conducting tracts, continuous from the adult region upwards to the tip. A like reference of the origin and disposition of these vascular tracts to the growing point itself appears to be equally justified. In fact the tip possesses the initiative for both.

The complex shoot that results from such initiation is exposed as it matures to external conditions which modify its form. Their effect is very obvious in the young shoot of the higher plants. As the shoot elongates its young tissues are soft and plastic. While in this state its form may be influenced by gravity, the incidence of light, mechanical contact and other causes which produce reactions of form called "tropisms." All these promote the well-being of the whole. The net result becomes fixed as the part matures, and its constituent tissues harden. Thus the adult form is the consequence of the primary initiation at the growing point, modified by the conditions to which the plant may have been exposed during the plastic period. This is a commonplace of the text-books. But amid all the careful analysis and experiment that has been devoted to the influences which thus affect form, one factor, insistent and unavoidable, has been habitually left out, *viz.*, the influence of size. Reference is occasionally made in text-books to the effect of surface tension in determining the simple form in minute organisms, such as unicellular algae and bacteria, and to the deviations from that simple form as the size increases and the influence of surface tension ceases to be dominant. At the other end of the scale of size mathematicians have calculated the extreme stature mechanically possible for a tree-trunk constructed after the ordinary plan, and of materials of known strength. The result is about 300 feet, and this coincides approximately with the limit of height of the canopy of a tropical forest. But in point of size practically the whole of the vegetable kingdom lies between the microbe and the forest tree. Unfortunately the study of these middle terms, from the point of view of change of form as the size increases, has not been pursued by botanists with the same perception as zoologists have shown in the study of animals.

At the back of all problems raised by increasing size stands the well-known principle of similarity,

[3] "Organographie," third edition, Part I, pp. 299–300.

which applies to all structures, inorganic as well as organic. It involves among other consequences that where form remains unaltered bulk increases as the cube, but surface only as the square of the linear dimensions. But in living organisms it is through the limiting surfaces, or "presentation surfaces," as they are called, that physiological interchange is effected. Provided a surface be continuous and its character uniform, it may be assumed that such interchange will be proportional to the area of surface involved. If, then, the form of the growing organism or tissue were retained as at first—for instance, a simple sphere, oval or cylinder—its surfaces of transit would increase at a lower ratio than the bulk which they enclose. There would be with increase in size a constantly decreasing proportion of surface to bulk, and as constantly an approach to a point of physiological inefficiency. But any change from a simpler to a more complex form would tend to uphold the proportion of presentation surface. Thus the success of a growing organism might be promoted by elaboration of form. Naturally other factors than that of size cooperate in determining form. Nevertheless the recognition of such elaborations of form, whether external or internal, as do tend in point of fact to maintain a due proportion of surface to bulk as growth proceeds should help to make morphology a rational study. The diffuse form habitual for plants, even the origin of leaves themselves, becomes intelligible from this point of view.

In the construction of any ordinary vascular plant there are three of these presentation surfaces, or limiting surfaces of transit, that are of prime importance: (1) the outer contour by which it faces the surrounding medium; (2) the sheath of endodermis which envelops the primary conducting tracts, and (3) that collective surface by which the dead woody elements face upon the living cells that embed them, through which water and solutes pass in or out. Each of these may vary independently of the others, and each would be a fitting subject for observation as bearing on this problem of size. But as a test case of the relation between size and form, it is the collective surface where dead wood faces on living cells that will meet our requirements best, for its study can be pursued among fossils almost as well as in living plants. The problem is one not merely of current physiology of the higher plants; it is one of adaptive progress. Accordingly measurements must be made of the wood of fossils as well as of living plants, and of young sporelings as well as of the adult.

We have seen that plants are essentially accumulators of material. A natural consequence of this is that primitive types, endowed with apical growth but with no secondary cambium, will enlarge from the base upwards. Any sporeling fern shows this. The leaves themselves increase in number; each successive leaf is as a rule larger than the one that came before, and the stem that bears them also expands upwards. In fact it takes the form of an inverted cone. To grasp the size-problem for primitive plants the mind must be rid of the idea of the forest tree, with its stem tapering upwards, for that is a state of highly advanced organization. The primitive form of stem is that of an inverted cone, enlarging upwards, with a solid core of wood within. A cone standing upon its tip is obviously unpractical. Not only is it mechanically unstable, but if the original structure be maintained so that the larger region above is structurally a mere magnified image of the smaller below, a constantly diminishing proportion of presentation area to bulk must needs follow, in respect of all the limiting surfaces. Such stems would all tend to become physiologically insufficient. Our immediate problem is with the woody column. How can that due proportion of presentation surface of the dead wood to the living cells, which physiologists hold to be essential, be maintained in the expanding stem, so as to meet the increasing requirements of transit and distribution of the sap?

This is not the place for a recital of the details of elaboration of the wood which have been observed and measured. It must suffice to state in general terms how primitive woody plants have met the difficulty in the absence of cambial thickening. The starting-point is a minute cylindrical strand composed of dead tracheids only. Some primitive types show nothing more than a conical enlargement of this upwards, with the cells more numerous than before. The approach of a locomotive at speed along a straight track may visually suggest such increase in size without change of form; successive photographs of it might be compared with successive sections of those simple stems enlarging upwards without change of plan. The largest examples of this are found in some of the early club mosses and ferns, in which there is an enlarging solid woody core. But for want of resources in this and other features they have paid the penalty of death. Most plants having this crude structure are known only as fossils, and no really large vascular plant lives to-day which shows it. Under present conditions it is only where the size is small that a simple mass of dead tracheids seems to be effective for water transit. Thus we see that simple enlargement without change of form does not suffice.

In more resourceful plants a remedy is found in elaboration of the form and constitution of the pri-

mary wood. The changes which actually appear in it, as the size of the individual or of the race increases, are very various, but they all tend towards making the wood a living whole. The most efficient state would be that in which each dead woody cell or element faces upon one or more living cells, and this structure is approached in modern types of wood. In tracing the steps which have led towards it, whether in the fossil story or in the individual life of plants, we follow up an evolutionary history of high functional import. Actual measurements and calculations have shown in living plants the advantage that follows. It has been found that changes in the elaboration of form and structure of the primary woody column have saved, in specific instances, about 50 per cent. of the contingent loss in that proportion of presentation surface to living tissue which would have followed if a simple cylindrical core had been retained. The structural changes do not, it is true, maintain the full original ratio of surface to bulk, but it may well be that saving even half of the contingent loss would bridge the acute risk and lead to survival.

The molding and subdivision of the primary conducting tracts as a whole, or of the woody masses which they contain, present the most varied features. Their contours often appear arbitrary and even irrational, so long as no underlying principle is apprehended. They have presented a standing problem to anatomists. But when it is realized that as the size increases there is a physiological advantage in any elaboration of form whatsoever, a rational explanation is at hand. The variety of the forms assumed suggests the common principle underlying them all, which is that thereby a due proportion of presentation surface tends to be maintained.

One of the simplest and most frequent examples of such elaboration of form is that of the fluted column, which in transverse section gives the familiar stellate figure characteristic of roots. It is also seen in many stems, and is described as "radial." Where the part is small the woody strand is roughly cylindrical, but where larger it often becomes fluted, with varying number and depth of the flanges. In many instances the ratio of their number to the diameter of the whole tract is approximately constant. The structure is in fact adjusted to the size. This is so in roots generally, in leafy stems and in leafless rhizomes—and a similar size relation is even found in the fluted chloroplasts of certain algae. In all these an obvious risk following an increase in size tends to be eliminated, *viz.*, an undue loss of proportion of surface to bulk.

The somewhat technical facts thus briefly described may be taken as examples of a relation of form to size which is very general. They suggest the existence of a size factor, which is effective in determining form. The susceptibility to its influence resides in the part that shows the results. The internal contours are defined *ab initio,* instead of coming into existence during the course of development, as is the case with the convolutions of the mammalian brain. In the stem and roots of vascular plants the fully matured conducting tracts may be traced upwards, with their outlines already defined, through successive stages of youth towards the growing point, which has been their source. Their form may be seen already outlined in its young tissue closely short of the extreme tip. This fact suggests that the susceptibility to the size factor resides in the growing point itself, for immediately below it those tracts possess that form which will aid their function when they are fully developed.

Of all the factors that contribute to the determination of form in growing organisms there is none so constant and inevitable in its incidence as this size relation. Its operation becomes manifest with the very first signs of differentiation of the embryonic tissues. The effects of other factors that influence form, such as gravity, light, temperature, contact and the rest, appear later in point of time. Their influence is liable to diminish as the organism reacts to them by curvature or otherwise, and to vanish when the reaction is completed. Under experiment they may be controlled or even inhibited. But the operation of the size factor is insistent; it can not be avoided either under conditions of nature or by experiment, though the size itself may be varied under conditions of nutrition and the permeability of the presentation surfaces may not be constant, with results as yet unknown. When we reflect that all acquisition of nourishment and transit of material in plants of primary construction is carried out through limiting surfaces, the essential importance of the size factor is evident, for upon its influence the proportion of each presentation surface itself depends.

The evidence that size itself is, among other factors, a determinant of form rests upon the constancy with which, in an enlarging organism, changes of primary form tend to maintain a due area of presentation surface such as active transit demands. That evidence has been derived chiefly from the conducting tracts of primary individuals as they enlarge conically upwards, and from parts belonging to distinct categories, also from comparison of different individuals not necessarily of close alliance. Very cogent evidence lies in the variety of the changes of form by which the same end is attained. Finally the converse facts bring conviction when, as often happens, a distal diminution of size in stem or leaf is accom-

panied by simplification along lines roughly the converse of those that follow increase. All this shows that a real relation exists between size and primary form. The term size factor has been used to connote that influence which affects form in relation to size, but without defining it except by its results. Nevertheless, we have seen that its action may be located in near proximity to the growing point, or in the embryo itself. It has not, however, been found possible to assign to that effect an immediate cause. The attitude thus adopted towards an undoubted factor seems justified by the broad logic of science and by the practice of its highest votaries. When Newton put together his great physical synthesis he pointed out at the close of the "Principia" that the cause of gravitational force was unknown. "Hitherto I have not been able to discover," he said, "the cause of these properties of gravity from phænomena, and I frame no hypotheses." Likewise, in its own more restricted field of botanical phenomena, the size factor may be recognized as effective in development, though the immediate cause of its effectiveness is still unknown.

The position thus adopted assumes the shoot to be a unit, not a congeries of "phytons." The elaboration of its form, whether external or internal, would be a function of the increase in size of that unit, and the result would tend to maintain the adequacy of the presentation surfaces. This conception of the shoot and of its parts would accord with the views of General Smuts, as stated in his remarkable work on "Holism," published in 1926. Many present here to-day will have heard his address in Cape Town last year, when opening the discussion on "The Nature of Life." All will value this masterly statement in brief of his theory. I suggest that the operation of the size factor, whether in relation to external leaf development or in the elaboration of internal conducting tracts, illustrates that "measure of self-direction" ascribed by him to every living organism.[4]

The discussion of the problem of size and form in plants, which has occupied our attention thus far this evening, raises questions of profound significance in the sphere of pure botany. There is, however, another interest inherent in the study of plants beyond that of pure science. I mean botany as applied to the needs of man. To-day this touches human life more closely than ever before. Every meal we eat, many of the clothes we wear, timber, rubber—a whole volume in itself—the drugs, narcotics, dyes and scents, and most of that vast tale of accessories that ameliorate life, depend for their supply, quality and often for their existence upon the skilled work of the botanical expert. He is trained in our schools and universities. His experience there is perfected by work on farms and plantations, in forests and in factories, often by adventurous life abroad. It would be superfluous for me to enter into detail on such matters, for happily the director of Kew presides over the botanical section, and he can speak with the fullest knowledge on the application of botanical science to modern life.

Government departments are now linked more closely than ever with universities and technical colleges by the golden chain of grants. The botanical institutes that have sprung from this joint source are mostly focused at such centers as Kew and South Kensington, Cambridge and Oxford, Harpenden and Merton, Long Ashton and Corstorphine, Plymouth and Millport, with important outliers such as Dehra Dun in India, the Imperial College of Tropical Agriculture in Trinidad and the Research Station at Amani, East Africa, while similar stations are to be found in Canada, at the Cape, in Australia and New Zealand. Their activities are as diverse as their positions. Agriculture, forestry, plant breeding and distribution, seed-testing, mycology and plant pathology —these are but a few of the headings under which applied botany is now pursued; and a duly qualified staff is required for each. Kew itself, thanks to the foresight of the Empire Marketing Board, is developing ever more and more as a coordinating center for the whole empire. Highly specialized study such as this has sprung into existence in the last half century. As regards Britain, its origin may be traced to the biological laboratory of the old Normal School of Science at South Kensington, where biological research was revived under Huxley and Thiselton-Dyer.

The first botanist there trained in pure science who turned the newly acquired vision to practical account in the interests of the empire was Marshall Ward. For two years he investigated the coffee disease that had half ruined Ceylon. It is a long step from this individual effort in the East to the firmly established and efficient Mycological Bureau, recently housed at Kew in a new building devoted to the world-wide study of the fungal diseases of plants. Such advance along a single line of applied botany may be taken as an index of the progress from simple beginnings in pure botany to that wide-spread attack now being made upon the economic problems that face imperial agriculture. The history of it thus briefly suggested may be read as a parable, showing how natural is the progression from the study of pure science to its practical application. For there is no real distinction between pure and applied science. As Huxley told us long ago, "What people call applied science is

[4] "Holism," p. 98.

nothing but the application of pure science to particular problems."

At the moment there is an unprecedented demand for botanical specialists to fill investigational and advisory posts at home and abroad, and there is a shortage of applicants. The realization of this will doubtless be transmitted through the universities and colleges to the schools of the country and lead to an increased supply. On the other hand, it lies with the government to react as other markets do in taking steps to equalize supply and demand. A condition of the success of a specialist will always be a thorough foundation upon pure science, and this will be fully realized in the selection of candidates. Government, whether at home or in the wider imperial field, can make no better investment than by the engagement of the best scientific experts available. In respect of botany this has been attested by many well-known instances.

Some reference will naturally be expected here to the remarkable address given by Sir William Crookes in 1898, when the association last met in Bristol. He then forecast that, in view of the increase in unit consumption since 1871 and the low average of acre-yield, "wheat can not long retain its dominant position among the foodstuffs of the civilized world. Should all the wheat-growing countries add to their area to the utmost capacity, on the most careful calculation the yield would give us only just enough to supply the increase of population among bread-eaters till the year 1931. The details of the impending catastrophe," he remarked, "no one can predict, but its general direction is obvious enough." The problem is one of applied botany, with a setting of world economics and a core of physical chemistry. After raising the specter of wheat shortage before the eyes of his audience of 1898, Crookes laid it again by the comforting words:

> The future can take care of itself. The artificial production of nitrate is clearly within view, and by its aid the land devoted to wheat can be brought up to the 30 bushels per acre standard.

We who are living within a few months of the fateful year of 1931 are unaware of any wheat shortage. Sir William Crookes' forecast of 1898 as to the advance in the production of combined nitrogen has been fully realized. Artificial fertilizers are not in view only, but at hand and in mass. Moreover, the northern limit of successful wheat culture has been greatly extended by the production of new strains with ever-shortening period between sowing and reaping, while the establishment of new varieties is extending the productive area in South and West Australia into regions where the rainfall is of short duration and restricted in amount. The future, since 1898, has indeed taken care of itself; so that, notwithstanding the warning of so great a man as Sir William Crookes, the wheat-eating public is still able to sleep well at night so far as the wheat shortage is concerned. What better example than this could we desire, not only of the importance of applied botany, but as showing also how its advance follows on research independently pursued? For the production of synthetic nitrogen, which has now become a commercial proposition, and the improvement of the strains of wheat by selective breeding along Mendelian lines, are both involved in solving this crucial question of food-supply. And both owe their origin to advances in pure science.

In conclusion, we shall all be conscious of the fact that a most distinguished former president of the association has lately passed away, one who more than any man has influenced the policy of government in relation to science. I mean Lord Balfour. We recall how in 1904 he, so thoroughly imbued with the spirit of his alma mater, presided over the meeting in Cambridge. He was distinguished as a philosopher, great as a statesman, and particularly so under the stress of war. He it was who, after peace returned, used his rare influence in transforming the war-time experiment of a committee of the Privy Council for scientific and industrial research into a permanent and essential part of modern government. But this was not all. His critical, constructive and experienced mind was led to formulate a still wider plan. A Cabinet Committee for Civil Research was to be established on the lines of the Imperial Defence Committee. He designed it so as to bring the whole national administration within the range of scientific influence. The Department of Scientific and Industrial Research, so wisely kept in being after 1919, now forms part of that larger scheme. This department is responsible for making recommendations as to the expenditure of funds voted by Parliament for research, especially in relation to industry. Thus science is welcomed into the inner circle of imperial administration. This the state owes to Lord Balfour.

And so in this hundredth year of its existence the British Association sees research recognized and fostered in the service of the state in a way never dreamed of in 1831, when a small body of enthusiasts met at York for the advancement of science. But though the individual seeker after truth may thus be involved in official harness, as of old an inner voice will yet speak to him. He will himself be as near to nature to-day as he was in the simpler days that are gone.

# MALPIGHI AS ANATOMIST[1]

By Professor A. W. MEYER

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IN these crowded days it is easy to overlook or forget what one owes to the past. The present is vocal and urging; the past silent and patient. Besides, life is so many-sided that no one can realize fully his entire indebtedness to the past, although the higher a civilization, the greater this golden heritage always is.

It is fortunate that we are willing to pause in a hurried day in order to pay our respects to a searcher who labored with great enthusiasm to almost the very end of his life in order to enlighten man regarding his own body. The name of Malpighi can never become a household word, but the debt that every one owes him nevertheless is great. There are no greater triumphs than those over ignorance and helplessness, over barbarism and brutishness. Hence it will be a sad day for civilization when the Malpighis are forgotten.

Although we are observing the tercentenary of his birth, Malpighi does not belong to the ancients. He was a modern anatomist, not only in his methods but also in his attitude and outlook.

As anatomist, Malpighi was not an observer of the dead alone. He was an experimentalist who worked much with living creatures of different kinds. He used both vertebrates and invertebrates as well as plants, and felt that there was a kinship among all living creatures, so that one could learn regarding the higher from an examination of the lower forms.

During all the time that he was professor of medicine he earnestly tried to reveal and understand the architecture of beings of all kinds, and to this end he used the microscope, chemicals, pigments such as ink, and the processes of maceration, boiling, injection, ligation, dissection and vivisection. How modern he was can best be illustrated by the fact that an enterprising medical student who copied from Malpighi's works over two hundred years afterward is recorded as actually having received a prize for his contribution to science.

It seems regrettable that Malpighi's anatomical studies had to be done largely during vacations and spare hours, for his interests did not lie in the single lane of the anatomy of his day. Worms, insects, fishes, amphibians and mammals of many kinds claimed his attention. He made contributions to embryology and to both gross and microscopic mammalian and human anatomy, and was in a large measure a founder of embryology and of the microscopic anatomy of organs. Indeed, Sir Michael Foster in his "History of Physiology" states that where Malpighi left embryology, it remained till the beginning of the nineteenth century.

It is true that Malpighi was in a sense a preformationist, for he had concluded that the chick is present in the incubated egg. This erroneous conclusion rested upon the observation that when hen eggs which had lain in a warm climate for some time were opened, it was found that development of the new individual had already begun, as indeed it has by the time a fertilized egg is laid. Moreover, since we now know that not all the cytoplasm of an ovum has the same potentialities, it is clear that present-day ideas of development might in some measure still be regarded as embodying a preformation hypothesis, although our ideas contain none of the early implications, and could we but go back farther in oogenesis with our experimental efforts, we would no doubt reach a stage in development in which the segregation of developmental potentialities probably had not yet occurred.

When Malpighi saw something new he was not content until others also had seen it, and some of his great discoveries are recorded in letters to his friends. That he took keen delight in his work is shown by his declaration that "in performing these researches so many marvels of nature were spread before my eyes that I experienced an internal pleasure that my pen could not describe." This devotion to practical studies caused him to be ridiculed, and he, like his great predecessor Harvey, was taunted by being asked how dissecting plants and watching the eggs of silkworms and hens hatch could possibly help cure the diseases of man. It is a strange commentary on modern life that there are those among us who still ask this same outworn question.

Since the labors of great men of the past often seem magnified by our forgetfulness of other workers in their field of activity and their time, it is well to recall briefly some of Malpighi's approximate contemporaries in anatomy. Among these were Bartholin, Bellini, Brunner, Cowper, du Hamel, de Graaf, Gall, Glisson, Highmore, Meibom, Nuck, Peyer, Riolan, Rivinus, Ruysch, Schneider, Steno, Swammerdam, Sylvius, Tulp, Wharton, Willis, Wirsung, etc. These names are known to all physicians, and most of them still are associated with parts of the human body, but Malpighi was greater than any of these. We still associate his name not with one but

[1] Remarks at the banquet of the Italy-American Society of San Francisco at the time of the tercentenary of Malpighi.

with a number of structures in human, comparative and plant anatomy.

Anatomy was beginning to flourish. The lymphatics had recently been discovered by Aselli; rickets was about to appear in the mortality tables of England, and quinine had just been introduced into Spain. The microscope had become known in Italy four years before Malpighi's birth, and Harvey's great work appeared the same year.

Malpighi was born a few years before Leeuwenhoek, and Thomas Sydenham, Thomas Willis and Robert Boyle were born a few years before him. Kepler had died a few years before the birth of Malpighi, and the temper of Italy was as troublesome, probably more so, than that of the England of Harvey. It will be recalled that Harvey wrote in "De Motu Cordis":

> But what remains to be said upon the quantity and source of the blood which thus passes, is so novel and unheard of a character, that I not only fear injury to myself from the enmity of the few, but I tremble lest I have mankind at large for enemies, so much doth want and custom that become as another nature and doctrine when sown, and that hath struck deep root, and respect for antiquity, influence all men; Still, the die is cast, and my trust is in my love of truth, and the candor that inheres in cultivated minds.

The Italy of Malpighi's day was rather less tolerant, for its learning was at a low ebb. There was very little in the life of seventeenth century Italy to encourage, but very much to discourage a pioneer. There were beacons of learning, however, and early in his career Malpighi joined the Accademia del Cimento of Florence, an organization for the experimental study of the physical sciences, and it is to his credit that he did not hesitate to go afield and experiment in the biological sciences as well.

When Malpighi was graduated from Bologna in 1653, as doctor of medicine and of philosophy, he was fortunate in being invited to join a small group, an anatomical club (Coro Anatomico) under the leadership of his later brother-in-law, Massari, who had been recommended to him as a preceptor in medicine. This zealous group of nine dissected human bodies and experimented on animals in Massari's own home, and this experience could not have been without influence upon Malpighi's career. However, he was a born anatomist, for he experimented and practiced dissections assiduously most of his life, though through a strange irony of fate he never held a professorship in anatomy, but professorships of medicine instead. Although he served in this capacity at Bologna, Messina and Pisa, and also was greatly honored by being called to be the private physician by Pope Innocent XII, enduring renown as a physician nevertheless does not seem to have been his. This is no reflection upon Malpighi, for his chief devotion was given to other things, although his contemporary fame as a physician is amply attested by his being called to fill professorships of medicine at several universities, sometimes at truly princely salaries.

Malpighi early realized the weakness of relying upon authority in anything concerning the works of nature, and thus antagonized those who blindly followed the errors of the great men of the past. Indeed, it was his interrogation of ancient authorities that caused him to lose favor and also preferment at his alma mater, where it seems he could rightly have expected to stay after his graduation in medicine. Although he tells us that he sometimes had recourse to the "eye of reason" when the microscopes, some of which he made himself, failed him, he was impatient with the views of Hippocrates and Galen on matters of structure and function. In his work on the kidney, Malpighi wrote:

> The fact that the human mind has pondered this and similar ideas about the kidneys throughout the ages stimulated me to further investigation . . . and be sure of this one thing, that I never reached my idea of the structure of the kidney by the aid of books but by the long, patient and varied use of the microscope. . . . Indeed, some people even introduce personal opinion against the indicated course of the urine in the papillary passages. . . . Do not stop to ask whether these ideas are new or old, but more properly whether they harmonize with nature.

Although Bowman's capsule was not discovered until 1842, and Henle's loop not until 1862, that is, approximately two hundred years later, Malpighi nevertheless firmly believed that the renal glomeruli are directly connected with the ureters. Although he could not prove this by means of injections of the ureters, arteries or veins, he held that both "reason and analogy" show that the glomeruli and ureters are united. He compressed the renal papillae and saw urine escape from the collecting tubules, and also ligated the ureter and vessels upon living animals and examined these after death, in order to demonstrate the relationship which he believed must exist between them.

Malpighi's contributions to anatomy were many and permanent, as the terms Malpighian corpuscle, layer and tubule attest. His description of the anatomy of the silkworm, of the human skin, of the liver, uterus, lungs, the kidneys, the spleen and the glands marked advances in many important respects. Indeed, in regard to some of these organs little was added to Malpighi's conception until long thereafter. This was true especially regarding the liver and kidney, and the incubating egg and silkworm.

Malpighi was both keen and ingenious and studied living things not only after but also before birth. His observations on the incubating hen egg form foundation stones in modern embryology. Although he thought that parts of the mature body were preformed in the egg he made a number of discoveries and accompanied the twenty-two quarto pages of description with eighty-four very good original drawings. Since this work in embryology was done before the days of thermometers and incubators, Malpighi also may have had to impress roosters for the service of hatching the eggs after the ingenious manner described by his great countryman, "L'Omo Universale," da Vinci.

Before Malpighi's day the ideas regarding the spleen and the pancreas were decidedly fanciful. The latter was looked upon merely as a cushion to help support the stomach, and regarding the spleen it was held that so-called black bile from the liver reached the stomach by way of the spleen either through the veins or by means of a special duct passing from the spleen to the stomach. Malpighi, who had ligated the vessels of the spleen in the living, scouted these ideas, and rightly maintained that the spleen has no duct, and that no material passes from it to the stomach. He thus corrected the false old notions upon which the current phrases "too much spleen" and "suffering from the spleen" are based.

It is not without interest to recall in this connection that a text-book of anatomy written by a self-styled anatomist, for one of the largest schools of manipulation in this country—a school whose graduates were authorized by the people of our state to diagnose and treat human ills—I say it is not without interest to recall that in this text-book of anatomy it is stated that: "Chiropractors have long maintained that the spleen furnishes a secretion that is used in the process of digestion" and that the spleen "has certain relations to digestion not yet understood." Indeed, the author of this text-book of anatomy is credited with having found during our time a duct leading from the spleen to the stomach, which was named after her. It is regrettable to think that some present-day Americans are willing, when ill, to be treated upon the basis of pre-Malpighian anatomy and physiology, and blindly wave aside the knowledge gained through the arduous and fruitful labors of great men of the past such as Malpighi.

Malpighi also discovered the sebaceous glands of the skin, and showed that the papillae of the tongue are not there to keep it moist. He showed that they are associated with nerves; believed that they had to do with sensation, and drew a similar conclusion regarding the papillae of the skin.

Every one familiar with the anatomy of the skin must have been perplexed by the fact that Malpighi spoke of the deeper portion of the epidermis as rete mucosum, for both these words seem thoroughly inappropriate. In all modern dissecting rooms the sloughing superficial layer of the skin includes the entire thickness of the epidermis, which, as is well known, is so thin in most areas that one must marvel how Malpighi could possibly have distinguished a deeper from a superficial layer. Hence it does not surprise one that Bichat denied that Malpighi had seen such a deeper layer in the epidermis, for as is common knowledge, the epidermis is separated as a single layer in connection with blisters, maceration and so forth.

It seems that Malpighi included in his work on the skin a study of bovine tongues, in which when boiled or macerated, or treated with an alkali, he could detach the superficial from the deeper portion of the mucosa, which under the circumstances had become clearer, somewhat swollen and more translucent than the superficial portion of the mucosa. Moreover, since only the interpapillary portions of the deeper portion often remained after detachment of the more superficial, the former contained perforations in the places of the papillae, when it was detached, thus giving him the impression that it was a meshwork or rete. Having observed these things in the thick mucous membranes of the tongues of bovines, Malpighi by analogy seem to have transferred the conception so gained to the human skin, for the idea that skin extends up into the nostrils and mouth had then but recently been advanced.

Malpighi rightly attributed skin color to pigment located in the epidermis, although this question remained a matter of dispute for almost two hundred years later. In 1823, Beclard, predecessor of Bichat, for example, still wrote: "The anatomical texture and composition of the skin are delicate points of anatomy that have greatly exercised the patience of observers and upon which they are far from agreeing."

Malpighi showed further that the trachea ends in small air sacs in the lungs, an observation which cleared the way for a truer conception of the rôle of breathing. Since Malpighi had shown that silkworms die in spasms "in the time it takes to say a *pater noster*," if the tracheae or breathing tubules on their bodies are coated with oil, it is indeed a little puzzling why he did not himself find a closer solution for the process of respiration. However, in doing these experiments on silk worms Malpighi was circumspect and emphasized that the nature of the oil is immaterial and that the worms die even if their bodies are coated with honey.

It is particularly significant for us of to-day that

many of Malpighi's discoveries were made by the aid of experiments on living creatures and that they could not have been made in any other way. It was impossible to see the natural motion of the blood except in living beings, and it was while observing the lungs and other organs of frogs, hedgehogs and turtles, under magnification, that Malpighi discovered the existence of tubular connections between the arteries and veins which we now know as capillaries. Regarding this discovery Malpighi wrote, "I see with my own eyes a certain great thing. . . . All this you will see exceedingly well if you examine the turgid lung of a frog with a microscope of a single lens against a horizontal sun." It was in such simple words as these that Malpighi recorded the crucial discovery which was needed to bring final proof of Harvey's conception of the circulation of the blood. One can not help but surmise that Harvey would have discovered the capillaries and so completed the entire story of the circulation himself, had it occurred to him to have recourse to the microscope available at the time. However, Harvey, a relatively aged man at that time, doubted the discovery of the lymphatics and could not be expected to turn to a new method of investigation in the evening of his life.

Malpighi found that nerve fibers run from the spinal marrow to the brain, and by dissecting the boiled hearts of cattle showed that the muscle of the ventricles is arranged spirally, a discovery which was not completed till two hundred and forty-four years later, in 1900, by a young Canadian anatomist, John Bruce McCallum, working at Johns Hopkins. It is true that Malpighi did not recognize the true nature of the brain of the silkworm, and mistook the red cells of the blood for "fat globules which looked like a rosary of red coral," that he thought the spinal nerves were hollow tubes and believed the gray matter of the brain which is scattered among the white to be glandular in structure, but he nevertheless was a very acute observer, and unusually gifted in reading the great book of nature. His descriptions and drawings alone are proof of this and he carefully explained his methods.

In the light of his day, it should not seem strange that Malpighi thought that the nerves were hollow, for the existence of a "succus nervicus" was then generally accepted, and when the doctors of that time used the phrase "caput purgiis" they meant it literally, for nasal secretion—rheum—was thought to represent impurities discharged from the brain, and spinal marrow—hence such expressions as "mourning of the chine." Moreover, the ducts of several glands had recently been discovered, and these were known to be hollow, and since Malpighi thought that the entire body including the brain was glandular, the conclusion that nerves were hollow and carry nourishment seems natural enough. Malpighi further thought that the finest particles of nutriment could pass directly to the nerves from the papillae of the tongue, for he reasoned that were it not so, "Wine taken into the mouth could not restore vigor presently."

The microscope then was a new tool, and it is no wonder that Malpighi was over impressed with what it revealed. The same thing happened to Leeuwenhoek, who demonstrated testes in maggots which he found in cheese, and to Swammerdam, who demonstrated all parts of the butterfly in the body of a caterpillar. It is interesting that the conception of glandular structure for the entire body was shared also by Wharton, the discoverer of the duct of the submaxillary gland, and by the great Dutch physician Boerhaave.

In order to reveal Malpighi's breadth of scientific interest, it is only necessary to read the following list of topics selected from the many that engaged his attention:

On a pregnant mouse.

Concerning the experience of extracting salt from minerals, fossils, etc., with common water.

The structure of the aorta of bovines.

The covering of stumps of sawed-off branches with bark.

On the spoiling of ground grains by honey dew.

The old trunks of laurels.

On various parts of elephants.

The sprouting of laurel seeds.

On ears of corn spoiled by moisture and honey dew.

A hair-like fistula in the human body.

The spermatic vessels of the dormouse.

An oak gall.

The hatching of the butterfly from the pupa.

The structure of the nests of wasps.

The omentum of the mole, the medulla of the silkworm and the uterine fetus of the hedgehog.

The eye of the night owl.

The motion of the heart of the locust.

On calculi in the guinea-pig.

The vesicles and spermatic parts of castrated horses.

The white fungus of wood.

The eggs of ground snails.

The pods of castor beans.

The noctiluca.

On the tench, the locust, the butterfly and on the oesophagus and eyes of cattle and the eyes of fishes, frogs and turtles.

On bull calves, snakes and "lucertolo."

On the pregnant and non-pregnant uteri of cattle.

On the worm and cricket.

The bones of fishes and the gall bladder and gall of bovines.

On the fat of the mole.

On human skin.

The pigeon pullet in the egg.

The feces of horses and the horns of cattle.

Observations on flies, snails, guinea hens and the guinea hen pullet in the egg.

Note on tubal pregnancy.

Note on the muscles of torpedo.

The gelatin found in the cranium of "piante."

On the structure of hair, feathers and snails, bones, teeth and gout.

Observations on the ear.

The seeds of lichens, mosses and ferns.

On tides.

On the optic nerve of the swordfish and a series of other vertebrates.

Malpighi was not only an anatomist, but also a zoologist, a botanist and physiologist as well as a practicing physician. He also took interest in physics and chemistry, and was known as a chemical physician. With his wide interests went tireless industry and an indomitable spirit which was not quenched by the loss of his instruments, home and manuscripts by fire at the age of 56 but endured to the end of his active life.

It is possible that what Haeser termed his confused style and often hardly comprehensible Latin may have been a factor in the lack of a broader recognition of his many achievements in his own day and ever since then.

It stands to the undying credit of England that the Royal Society of London invited Malpighi to correspond with them, and elected him to membership. Almost all his papers written after he went to Bologna were published by that society, as Harvey's immortal work had been published in Frankfort.

Although the stirring things which happened in Malpighi's days may have spurred him on, I think that we must grant that his fruitful labors were the product of his genius and not of his day. The microscope, injections and other advances in technique were equally available to others, but no one used them to such good advantage as Malpighi. He stood at a new era, and spoke with a new voice. He was not a child of his time and his was a magic hand which illumined all it touched. His methods were objective and experimental, thoroughly modern and scientific in every way. He was an experimental, physiologic anatomist.

I have endeavored to recall very briefly some of Malpighi's services to mankind. My tribute is of necessity incomplete and inadequate, but fortunately his accomplishments speak eloquently for him. It is to these that one must turn in order to realize more fully what he did for all of us. We may not all be his friends, but all of us are his debtors.

# SCIENTIFIC EVENTS

## UNVEILING OF TABLET TO SIR WILLIAM AND SIR JOSEPH HOOKER

ON Sunday, August 17, in connection with the meeting of the International Congress of Botanists, a tablet was unveiled at the parish church of St. Mary's, Halesworth, East Anglia, England, in memory of the famous botanist and first director of the Royal Botanic Gardens, Kew, and his equally famous son, the second director of Kew, Sir Joseph Hooker.

The tablet was unveiled by Lieutenant-Colonel Sir David Prain, a former director of Kew, and the dedication was by the bishop of St. Edmundsbury and Ipswich, who also gave an address from the text, Psalms 104, verse 24. The bishop stressed the importance of open-mindedness on the part of ecclesiastics toward the findings of science and the equal importance of a similar attitude on the part of scientists toward religious thought and work. The Scripture lesson was read by Lord Ullswater, former speaker of the House of Commons and chairman of the tablet committee. The arrangements were carried out by Professor Oliver.

The tablet was designed by Mr. A. H. Gerard, of the department of sculpture, Slade School, University College, London. The design of the lower border of the tablet is an overlapping of the corollas of certain rock garden flowers to symbolize plants growing close to the ground. The side-border design is of conventionalized flowers of a species of heath, magnified forty times, symbolizing plants that grow up into the air. At the center of the top border is represented the sun, without which plant life would not be possible, and on this border are also five conventionalized birds, symbolizing the dissemination of seeds. The design is carved in incised relief, a method used by the Egyptians some 3,000 years ago.

Medallions of the tablet will be cast by Wedgwood to supply orders received.

Sir William Hooker lived in Halesworth when a young man, and was unsuccessful in his attempt to conduct a brewery adjacent to the family home where Sir Joseph was born. When the latter was about four years of age his father abandoned business and adopted botany as a career. In this profession it was early predicted of him that he was "likely to become a person of some importance."

Among those who attended the ceremony of unveil-

ing the tablet were two sons of Sir Joseph Hooker (neither of whom went into scientific work), and the present director and assistant director of Kew.

The inscription on the tablet reads as follows:

This tablet records the association with Halesworth of Sir William Hooker and of his son, Sir Joseph, who in succession became the directors of the Royal Botanic Gardens, Kew. Sir William Hooker lived in Halesworth from 1809 to 1820, and here Sir Joseph was born in 1817. Erected, 1930.

Those attending the exercises visited the house and room where Sir Joseph was born.

C. STUART GAGER

## INTERNATIONAL SOCIETY OF EXPERIMENTAL PHONETICS

THE first Congress of the International Society of Experimental Phonetics was held at Bonn from June 10 to 15, 1930. Over 100 people attended. Addresses and demonstrations referring to all parts of the science of speech were presented.

Dr. Gutzman (Berlin) gave a striking demonstration of a Röntgen speech film in which the movements of the larynx, hyoid bone and tongue appeared with great clearness. This will shortly be combined with a speaking film so that the movements of the organs can be seen and the speech be heard at the same time. The possibilities of this method for the investigations of speech from a linguistic point of view can not be overestimated. It is also adapted to purposes of instruction, for example, of the deaf.

W. Lenk (Vienna) demonstrated a speech film apparatus suitable for laboratory use in scientific investigations. The speech may be recorded not only in the constructed form necessary for reproduction but with lengthened waves adapted to measurement. Dr. Moses (Cologne) showed that speech records vary according to the character of the person. Professor Scripture (Vienna) gave a presentation of the puff theory of the vowels. F. Janvrin (London) presented the results of an experimental analysis of a record of verse spoken by John Galsworthy himself.

Professor Isserlin (Munich) discussed aphasia; Dr. Berger (Münster) presented phonetic investigations of the Lombard Test; Dr. Kaiser (Amsterdam) showed registrations of pathologically altered voices. Dr. Hegedüs (Gödöllö) showed curves from experimental investigations on the melody of Hungary. Dr. Peters (Tartu) presented an analogous result from Esthonia.

In a paper on speech atoms and speech molecules Professor Scripture demonstrated that speech consists of a series of minute portions which for the purpose in hand can be treated as constant; these he termed "speech atoms." The combination of speech atoms into larger units such as words, sentences and so on he termed "speech molecules," according to the definition that a speech molecule is any portion of speech spoken as a unit. He showed that speech atoms influence one another when combined into molecules; the forces that act were termed "intramolecular forces." The fact that a speech atom in the latter part of a molecule can influence atoms that preceded it was considered to be a proof that each molecule was present as a whole at some time previously in the unconscious mind.

The exhibition included various oscillographs, film apparatus, graphic registration apparatus, harmonic analyzers and numerous other devices. An account of the proceedings will be published as a separate volume.

At a meeting of the council, the secretarial bureau was definitely located at 73 Welbeck Street, London, W.1, and arrangements were made to send the following publications free of charge to the members: *Zeitschrift für Experimentalphonetik, Bulletin of the International Society of Experimental Phonetics, Bulletin de la Société Internationale de Phonétique Expérimentale* and *Sprachneurologische Mitteilungen.* The membership fee was fixed at 10 shillings per annum.

Professor Hugo Pipping (Helsingfors) has been made an honorary member of the society.

## THE INTERNATIONAL HORTICULTURAL CONGRESS

AT the last session of the International Horticultural Congress, on August 15, Dr. M. J. Sirks, honorable secretary, presented the report of the committee on nomenclature, whose resolutions included the following:

A list of names valid at the time it is made should be drawn up and should be good for, say, six years. It is imperative that this list should follow strictly the rules of botanical nomenclature so far as species and botanical varieties are concerned, and that the names of plants generally accepted as conformable to the rules at the time of the making of the list should alone be used. All personal preferences and individual usage must be sunk if not in conformity with these rules. This list should be used universally in catalogues, horticultural literature, and gardens for a fixed period. An international committee should be appointed to revise this list in the light of botanical research at intervals of six years. Such alterations as are admitted at these revisions should be shown thereafter in catalogues for the next period with the superseded name as synonym.

It was added that so far as possible names of horticultural varieties should consist of a single word; the employment of not more than three words is per-

mitted as a maximum. Varietal names already in use for one variety of one kind of plant should not be used again for another variety of that kind, even though they may be attached to a different species.

The committee also decided that where personal names are used to designate varieties the prefixes, Mr., Mrs., Miss and their equivalents should be avoided; that excessively long names and words difficult to pronounce should be avoided; and that the articles "A" and "The" and their equivalents should be avoided in all languages where they do not form an integral part of the substantive—*e. g.,* Colonel, not The Colonel; Giant, not The Giant; Bride, not The Bride. Existing names in common use, it was stated, should not be altered to conform to these rules, but attention should be paid to them in all new names proposed.

It was suggested that the starting point for nomenclature of horticultural groups should be some recognized horticultural monograph; or an *ad hoc* list of varieties drawn up by a recognized body of specialists in the particular group; or, where such bodies do not exist, by some recognized society which shall be specially charged with the work.

## SCIENTIFIC AND TECHNICAL SOCIETIES

ONE of the most outstanding phases of modern life is the banding together of those with a common interest and cause into associations and societies for mutual benefit. Scientific and technical men have not been slow to see the value of this pooling of interests, and the outcome has been the forming of hundreds of such societies with the general object of fostering, protecting and promoting the various professions represented.

The Handbook of Scientific and Technical Societies and Institutions of the United States and Canada has recently appeared in a second edition revised and considerably enlarged, presenting 793 societies and institutions in the United States devoted to science and its technologies, and 91 in Canada. The section for the United States was compiled by the Research Information Service of the National Research Council, and that for Canada by the National Research Council of Canada. Detailed indexes for both sections, giving the subjects covered by the societies, their research funds, publications, changes of names, etc., make the book usable from many different points of view. In the body of the publication, the secretary's name and address, number of members, times of meetings, dues, etc., give a fairly complete summary of the activities and purposes of the societies.

The purpose of the book, as stated in the preface, is "to present a ready guide to those scientific and technical societies, associations and institutions in the United States and Canada which contribute to scientific knowledge or further research through their activities, publications or funds." The tendency has been towards a broad interpretation of these requirements, several small and, perhaps from a scientific standpoint, less important societies having been included in an attempt to cover the ground as thoroughly as possible. The emphasis, in fact, is frankly on making the publication inclusive rather than exclusive.

Those who are looking for information on university or governmental organizations will not find it here. A very few outstanding bodies, such as the Smithsonian Institution, the National Advisory Committee for Aeronautics, the Scripps Institution of Oceanography, have been included as having more than the usual university or governmental interests. The general rule, however, has been to omit organizations directly under such control.

## CELEBRATION BY THE MISSOURI BOTANICAL GARDEN

THE three hundredth anniversary of the first use of Cinchona will be celebrated at the Missouri Botanical Garden, St. Louis, on Friday and Saturday, October 31 and November 1, 1930.

The program opens at 10 o'clock with a trip through the conservatories, chrysanthemum show, and an exhibition of books, pictures, crude materials and drugs pertaining to Cinchona.

The address of welcome, at 11:30, will be given by Dr. George T. Moore, director of the garden. This will be followed by a symposium on the history of Cinchona; the speakers and subjects being as follows: "The Drug," by Professor Leo Suppan, St. Louis College of Pharmacy; "The Chemical," by Dr. Edward Kremers, University of Wisconsin; "The Medicinal Use," by Dr. George Dock, Pasadena, California.

At one o'clock there will be a luncheon at the garden followed by lectures at two o'clock on: "The Cinchona Industry of Java," by Dr. M. Kerbosch, director, Government Cinchona Estate and Cinchona Experimental Station, "Tjinjiroean," Pengalengan, Java; "The Pharmaceutical Preparations of Cinchona," by Dr. Wilbur L. Scoville, Detroit; "Minor Alkaloids of Cinchona Bark," by Dr. Frederic Rosengarten, Philadelphia; "The Cinchona Alkaloids in Medical Science," by Dr. Torald Sollmann, Western Reserve University, Cleveland, and "The Present Conception of the Action of Quinine in Malaria," by Dr. Kenneth F. Maxcy, University of Virginia.

The banquet, given by the trustees, to be held at

Hotel Jefferson, will be presided over by Judge George C. Hitchcock, president of the board. The speakers include Dr. A. R. Van Linge, N. V. Nederlandsche, Kininefabriek, Maarssen, Netherlands.

On Saturday visitors will go to the new Missouri Botanical Garden extension to view the orchid collections. A barbecue luncheon will follow at 1:00 P. M., after which trips will be taken to various parts of the grounds. A bus will leave for the city at 3:00, 4:00 and 5:00 P. M. A reception at the director's residence will be held in the evening from 8:00 to 10:00 o'clock.

# SCIENTIFIC NOTES AND NEWS

THE honorary degree of doctor of laws from the University of Manitoba was conferred on Lord Dawson of Penn, physician to King George, and on Lord Moynihan of Leeds, at the meeting of the British Medical Association in Winnipeg.

DR. MAX PLANCK, emeritus professor of theoretical physics in the University of Berlin, has been elected president of the Kaiser Wilhelm Society for Advancing Science, Berlin, under the control of which are the various Kaiser Wilhelm Institutes.

THE Albert Medal of the Royal Society of Arts has been conferred on Professor H. E. Armstrong for his discoveries in chemistry and his services to education.

ON account of his work in behalf of rheumatic children, Dr. Frederick J. Poynton has been given the first award of the Dawson Williams Memorial Prize of the value of fifty guineas. Dr. Poynton is senior physician to the Hospital for Sick Children, London. The prize represents the interest accruing from collected funds commemorating the work of the late Sir Dawson Williams, editor of *The British Medical Journal*.

DR. E. C. KENDALL, of Rochester, Minnesota, has been elected president of the Association for the Study of Internal Secretions for the year 1930–31.

MR. K. G. MACKENZIE, consulting chemist for The Texas Company, was elected president of the American Society for Testing Materials at its recent thirty-third annual meeting, held at Atlantic City. Cloyd M. Chapman, a consulting engineer of New York, was elected vice-president. The members of the executive committee include F. H. Jackson, Zay Jeffries, H. H. Quimby, G. A. Reinhardt and H. N. Van Deusen.

DR. H. L. RUSSELL, dean of the College of Agriculture of the University of Wisconsin, who recently resigned, will become executive manager of the Alumni Research Foundation of the university.

AT the first meeting of the permanent committee of the International Union of Forest Experiment Stations, M. H. Biolley, forest inspector, of Neuchatel, Switzerland; Kammerherr von Kalitsch, of Bärenthoren, Germany, and Henry I. Baldwin, research forester, of the Brown Company, Berlin, New Hampshire, were elected associates of the union.

DR. HERBERT C. HANSON, associate professor of botany and associate botanist in the Colorado Agricultural College, has been appointed head of the college department of botany and station botanist at the North Dakota Agricultural College.

MR. H. NORRIS SHREVE, consulting chemist of New York City, has been appointed to the faculty of the school of chemical engineering of Purdue University. He will take charge of the work in organic technology.

ELEVEN new members of the Texas Technological College faculty have been chosen to replace those who are taking leaves of absence for the year 1930–31. They include Miss Mamie Klett and Paul D. Voth, biology; R. C. Goodwin, head of the department of chemistry of the University of Florida, and C. H. Connell, chemistry; H. H. Pfarr, Ohio University, business administration; Venton L. Doughtie, a graduate of Texas University, electrical engineering, and H. F. Godeke, mechanical engineering.

MR. EDWARD W. GIFFORD, formerly curator of the museum of anthropology at the University of California, has been appointed lecturer in anthropology at the University of Washington.

DR. A. F. SCHALK, head of the department of veterinary medicine and station veterinarian at the North Dakota Agricultural College, has resigned to accept the chairmanship of the newly established department of preventive veterinary medicine in the Ohio State University.

DR. J. A. CARROLL, of Sidney Sussex College, Cambridge, has been appointed to the chair of natural philosophy at the University of Aberdeen.

MR. J. ALFRED HALL, a graduate of the University of Wisconsin, has been appointed plant chemist in the Forest Products Laboratory, Madison, Wisconsin. He goes to Madison from Duke University, where he has been chief chemist of the chemical laboratory established under the Liggett and Myers Research Fellowships since 1928.

MR. PHILIP D. ADAMS, instructor in the department of agricultural and biological chemistry at Pennsylvania State College, has resigned to accept a position as research biochemist at the Skin and Cancer Hospital of Philadelphia.

DR. FRANK D. MOORE, president of the Chicago Chapter of the American College of Surgeons, has sailed for Europe to make a tour of European clinics.

PROFESSOR H. L. BOLLEY, botanist of the North Dakota Agricultural Experiment Station, has been granted a year's leave of absence for a study in South America of flax and other crops.

THE *Experiment Station Record* reports that Clyde McKee, head of the department of agronomy and vice-dean, and John A. Nelson, head of the dairy department, Montana Agricultural College, have been granted leave of absence for one year for study. In their absence A. H. Post, associate professor of agronomy and assistant agronomist, and Glenn C. Sands, instructor in dairy industry, will be acting heads of the respective departments.

DR. WAYNE J. ATWELL, professor of anatomy at the University of Buffalo, has returned from a two months' European trip during which he attended the international Anatomical Congress at Amsterdam and visited a number of anatomical laboratories.

OFFICIAL delegates of the United States to the International Congress of General Mechanics to be held at Liége from August 30 to September 7, 1930, are E. J. Rossback, Chicago, treasurer of the Association of American Engineers in France; T. A. Vander Willigen, Philadelphia, of Humphreys and Glasgow, and Millard Shaler, Portland, Oregon.

THE United States government has accepted an invitation from the French government to participate in the first International Congress on Aerial Safety, which is to be held at Paris from December 10 to 23. The American delegates will be Fayette W. Allport, commercial attaché at Paris; William L. Finger, automotive trade commissioner to Europe; Lieutenant Commander George D. Murray, assistant naval attaché at Paris; Major R. L. Walsh, assistant military attaché for air at Paris, and John J. Ide, technical assistant in Europe of the National Advisory Committee for Aeronautics.

WE learn from the *Journal* of the American Medical Association that visiting lecturers at the School of Tropical Medicine, Porto Rico, for the ensuing year will include Colonel Charles F. Craig, editor of the *American Journal of Tropical Medicine* and director of laboratories at the Army Medical School, Washington, D. C., and Dr. Theobald Smith, formerly director of the Rockefeller Institute at Princeton, N. J. Dr. Earl B. McKinley, San Juan, director of the School of Tropical Medicine, is spending the summer as visiting professor at the University of Chicago, where he is conducting a course on filtrable viruses and rickettsia diseases.

THE general subject of the Hitchcock Lectures to be given by Dr. John C. Merriam, president of the Carnegie Institution of Washington, at the University of California on September 2, 3, 8, 10 and 11, is "Nature and our Philosophy of Life." The titles of the individual lectures are: "Interpretation of Nature as Influenced by Present-day Science"; "Significance of Evolution to the Individual"; "The Poet as Interpreter of Nature"; "Educational and Spiritual Influence of Nature in its Greater Features," and "Appreciation of Nature in Day-to-day Living."

THE Seventh International Tuberculosis Congress opened at the University of Oslo on August 12. Professor Frölich delivered the opening address. There was a large attendance of French, German, Italian and Americans.

ON October 20, the Biological Club of the University of Minnesota will celebrate its three hundredth meeting. This organization is limited in membership to a small group of workers actively engaged in investigation and teaching in the broad field of the biological sciences. Meetings are held biweekly throughout the academic year, and each year some topic of general biological interest is studied, the entire year being spent on intensive study of that phase of biology. We are requested to state that past members of the organization are urged to be present at this celebration.

THE U. S. Civil Service Commission, Washington, D. C., announces the following open competitive examinations: Senior chemist, with an entrance salary of $4,600 to $5,400 a year; chemist, $3,800 to $4,600 a year, and associate chemist, $3,200 to $3,800 a year. Applications must be on file not later than October 1, 1930. The examinations are to fill vacancies in the federal classified civil service in Washington, D. C., and in field branches. Applicants may select as optional subjects any of the following: (1) Advanced inorganic chemistry; (2) industrial engineering; (3) organic chemistry; (4) physical chemistry; (5) physiological chemistry; (6) any other specialized branch of chemistry. Competitors will not be required to report for examination but will be rated on their education, training and experience, and upon published writings or a thesis.

FOR the last four summers, the departments of botany and zoology of the University of Pittsburgh have conducted classes and carried on investigations

at the State Fish Hatchery and at the biological laboratory on Presque Isle, at Erie, Pennsylvania. There has now been organized the "University of Pittsburgh Lake Laboratory," as a department of the graduate school of the university, with Dr. O. E. Jennings, head of the department of botany, as director, and with Dr. S. H. Williams, professor of zoology, as associate director. Most of the activities of the laboratory will be devoted to classes and to investigation during the summer months, but some year-round investigations, such as that of Mr. Gottschall on the phyto-plankton organisms, will also be undertaken. The varied and rich life of Presque Isle peninsula and of the adjacent bay and lake waters offers attractive opportunities for study and investigation.

WE learn from *The Collecting Net* that Dr. William C. Harrington, formerly of the International Fisheries Commission, has joined the staff of the U. S. Bureau of Fisheries at Woods Hole, Massachusetts, to investigate the problem of the changes in the abundance of haddock with special reference to possible depletion.

THE fertilizer department of the Anaconda Copper Mining Company has given $5,000 to the Montana Agricultural Experiment Station for a study of the value of commercial fertilizer. Mr. I. J. Nygard is in charge of research.

THE State Institute of Public Health of Oslo was formally opened on August 16, Dr. Bally representing the Rockefeller Institute. The institute includes three buildings equipped with the most modern apparatus for the speedy and exhaustive treatment of illness, and with laboratories for research and for dealing with the spread of disease. The whole block of buildings cost about £195,000, of which the state contributed approximately £83,000. With a donation of £61,000 from the Rockefeller Institute, it has been possible to complete the institute. Dr. Wefring, the medical director of the institute, in his opening address referred to the gift, and warmly thanked Dr. Bally not only for the support given by the Rockefeller Institute to the Swedish Institute, but also for the aid he had personally rendered in completing the work. The Tuberculosis Congress was officially closed recently, and a great part of the members are now making a tour of the country.

BY the will of Mrs. Julia Brill Patchett, of Merion, Pennsylvania, the University of Pennsylvania becomes the ultimate beneficiary of a fund of $300,000.

ORGANIZATION of an administrative council for the Eastman Dental Clinic Foundation, to be established with a $1,000,000 gift made last year by Mr. George Eastman, of Rochester, has been completed and the inauguration of the foundation for active work was set provisionally for 1932. Balbino Giuliano, minister of education, presided at a meeting of the council which brought praise of the American philanthropist as a great benefactor to humanity. The council includes Professor Amedeo Perna, *president;* Dr. Ugo Frascarelli, director general of the ministry of education; Dr. Gaetano Basile, supervisor of public health; Professor Giovanni Perez, director of the institute of pathological surgery at the University of Rome; Dr. Mario Romanalli, an official of the ministry of finance, and Dr. Enrico Vallerina, of the ministry of education. Professor Aldo Foscheni, architect, is a consulting member.

CONCERN is felt for the future of the Royal Botanic Society because the lease of the gardens in Regent's Park expires in April, 1932. According to the London *Times,* the opinion is expressed that the society may find it impossible to continue. Mr. Henry W. Woodford, the secretary, stated recently that there was no alternative site in London and, although Mr. Lansbury, the first commissioner of works, has said that no doubt provision would be made for carrying on horticultural research work, there was no indication of the way in which it could be done.

THE Alabama Polytechnic Institute and the Bureau of Standards are about to begin a cooperative research on starch at the newly opened chemical laboratories of the institute at Auburn, Ala. This investigation will have to do primarily with the starches found in crops in the South. A study will be made of the uses of starch in the manufacture of textiles, and the properties required in starch for each use. Further, it is planned to determine whether starch from one source is superior to that from another for given purposes, and if specific starches may be modified so as better to adapt them for particular uses.

# DISCUSSION

## CHEMICAL ACTIVATION OF QUARTZ SURFACES

IT is well known that certain classes of filters operate not by straining but by selective adsorption on exposed surfaces. A yellow gasoline is readily filtered water white with fuller's earth, the yellow coloring matter and other unsaturated hydrocarbons being adsorbed in preference to the paraffins by the acid,

open-bonded silicates. Animal and vegetable oils, fats and juices containing hydroxyl groups are freed from color by charcoal or weakly basic silicates.

An adsorption filter of the silicate or hydrous oxide (Fe, Al) type normally has terminal H and OH in place and in that condition will adsorb bases for which its attraction is stronger than for these groups. Heating to about 200° C. drives off most of the H and OH as water and leaves the filter capable of adsorbing even weak free bases.[1] Certain pure quartz oil sands are known (Tensleep, Oregon Basin, Wyoming) having a thick brown adsorbed coating which can not be washed off. Oxidation with chromic acid leaves a pure white quartz crystal. The coating is about 0.7 micron thick. It will readsorb on soaking the cleaned sand over night in the heavy crude from that field.

These Tensleep quartz grains must then have been chemically activated by natural processes. What these processes are is well worth knowing from either a geological or commercial standpoint. A laboratory study soon showed that the activation of even crystalline quartz is neither difficult nor complicated. A sea sand may be given the adsorbing properties of the Tensleep very readily.

The plan was to attack the surface of the quartz with a strong alkali, forming a layer of alkali silicate over the surface, replace the base by hydrogen by means of an acid treatment, then drive off the H and OH by heating, leaving open bonds. KOH solutions would doubtless serve for the first step but are too slow. A bath of fused sodium or potassium carbonate (at 850° C.) is too violent, but fused potassium hydroxide (at 350° C.) worked very well, and did not crack even crystals of considerable size. A minute or two was sufficient time. Boiling in HCl, followed by thorough washing and drying completed the activation. The test was to soak in heavy crude over night. Fine sand and clay was tested by percolation through two inches of sand in a tube.

Since the object of the chemical treatment is to open up the $SiO_2$ bonds over the surface, it should be possible to dispense with the initial alkali treatment. Quartz or sea sand given a brief bath of hydrofluoric acid were found to be activated just as well as when given the alkali and HCl treatment.

It is hoped that these simple experiments may throw additional light on the still obscure mechanism of surface reactions and selective adsorption. Activated surfaces of pure quartz are excellent filters per unit area and their filtering action is pure chemical.

P. G. NUTTING

U. S. GEOLOGICAL SURVEY

[1] P. G. Nutting, *Economic Geology*, May, 1926, and November, 1928.

## A CELESTIAL SEARCHLIGHT

A NARROW beam of light, suggestive of a searchlight beam, stretched across the sky from west to east, approximately through the zenith, the evening of August 21, 1930. The point of observation was 3.5 miles north of the center of Littleton, New Hampshire, and the time, 9:50 to 10:15 P. M., E. S. T. For the first 15 minutes the beam appeared brightly over the western horizon, which was 20° above a horizontal, passed through the zenith and faded in cirro-stratus clouds about 20° above the eastern horizon. During the last ten minutes the beam was distinctly south of the zenith and during the last five faded rapidly and broadened till it was scarcely noticeable. Rough angular measurements showed that the beam was about 5° wide and that it was moving southward about 10° in 10 minutes. Vega was the center of the beam about 9:57 P. M.; at the northern margin at 10:00, and from more than 5° at 10:07 to 10° from it at 10:10 P. M. There was a general auroral glow in the northern sky during this beam phenomenon, and at 10 there was a temporary appearance of an auroral streamer in the N x E. The color of the lights was the usual auroral pale greenish yellow.

A beam of the same sort was observed by the writer two or three years ago at Silver Lake, New Hampshire. It seems that these beams may be narrow auroral arches that lose their arch-like appearance and become like straight beams when overhead.

CHARLES F. BROOKS

CLARK UNIVERSITY

## A SURFACE TENSION EFFECT

DURING the course of a microscopic investigation of certain oil products, great difficulty was experienced in deciding whether or not certain small spherical appearances were air bubbles. The optical behavior of these particles (diffraction rings, refractive shadows, etc.) closely resembled the appearance of air bubbles but were not quite identical. For use in direct comparison, air bubbles of about the same size were made by violent agitation of Nujol with air. A small portion of this Nujol containing bubbles ranging from 3 μ to about 5 μ was mounted under a standard cover-glass (.18 mm thick) and studied by different illuminations with a 6 mm objective and 20× eyepiece.

While one of the smaller of these bubbles was being studied it disappeared between observations. After looking for it in some other portion of the field and not finding it, it was considered probable that its disappearance was the culmination of surface tension action. Another small bubble was picked out and carefully watched. At a diameter of about 5 μ its shrinkage became rapid enough to be measurable

with the filar micrometer from minute to minute. This rate of shrinkage increased, apparently as a parabolic function of diameter. At about 3 μ it became rapid enough to be followed by continuous observation. At about 1½ μ one side of the bubble seemed to collapse and the bubble instantly disappeared. The duration of the collapse and disappearance seemed to be from about 1/5 to 2/5 seconds. This observation was repeated again and again, starting with bubbles about 4 μ to 6 μ, and the same phenomena were always observed.

Calculation from the surface tension of the Nujol (assumed as 44 dynes) indicates that if the ordinary surface tension values hold for bubbles of this diameter (as is probably the case) the pressure within the bubbles rises to a value of about 8 pounds per square inch above atmosphere, when the bubble begins to show continuously observable shrinking, and rises to about 16 pounds above atmosphere at the time of collapse.

Believing that the resulting increase in the amount of air thus forced into solution should be reflected in the behavior of larger bubbles, the diameters of the larger bubbles were carefully observed with the filar micrometer, and they did, in fact, show growth, although it was so slight that it would not have been noticed without careful measurement. The effect has not been studied either with other gases or with other liquids such as aqueous solutions, but there seems to be little reason to expect any differences except those of degree.

The primary purpose of the experiment was excellently served. In the microscopic preparation being studied, the rounded particles suspected of being air bubbles varied from about ½ μ to about 5 μ and the various sizes frequently occurred in close proximity to one another. It was, therefore, possible to say positively that the rounded particles could not possibly have been air bubbles because the experiment proved that bubbles less than about 3 μ diameter could not be stable in such liquids. The larger bubbles grow and the smaller vanish by loss of gas to the liquid and thence to larger bubbles or to any exposed surface.

So far as known, this effect has not been previously observed and recorded. Once considered, however, it should obviously be expected, although a number of scientists to whom it was mentioned have at first doubted its possibility. Attention is called to it because it may provide a method for studying the degree to which normal surface tension laws continue to hold true for highly curved surfaces and also because this effect explains many phenomena not hitherto made wholly clear. It sheds light on the ready clarification of sirups, lacquers and other highly viscous solutions in which minute bubbles could not be expected to reach the surface in any reasonable length of time. It indicates a contributory factor in mineral froth flotation by mechanical agitation. It serves to explain the ease with which liquids may be highly supersaturated with gases and certain apparently anomalous phenomena observed in the absorption of gases in towers, tanks, tourilles, etc. It gives a clearer understanding of the sudden and violent "bumping" of superheated liquids.

It may even be found to have a physiological bearing on the condition of dissolved gases in the blood stream, and the consequences of marked changes in pressure, as in aviation.

WM. M. GROSVENOR

## COLLEGE TRAINING FOR THE FISHERIES

ALL successful men have an education. Some get it without going to school and some get it after going to school. Yet the college education may be a very helpful step-ladder to success. As to the kinds of trained required for success in the fisheries field there is much confusion of thought. This is due to the lack of a proper analysis of the various branches of the fisheries into which one may embark. The biologist thinks largely in terms of biology, the technologist in terms of chemistry, physics and engineering, and so on ad hominem. Few have really analyzed the fisheries field in its entirety, breaking it down into fundamental lines of equal rank but quite different in the character of training required. This discussion is written with the hope of clarifying the situation and aiding students to map out educational courses with definite objectives in view after graduation.

Before actually outlining these fields, first let us break down the prospective personnel into three groups of persons: (1) Those bent on becoming highly trained key men in their respective fields; (2) those of good education or wide experience upon whom the first group must largely depend for the carrying through of their particular program; (3) those with limited capabilities for advancement either through lack of training or for other reasons.

In this age of specialization the key men must be highly trained, each in a particular field. What are these specialized fisheries fields and what classes of positions are open? These are four in number—fisheries biology, economics, technology and administration. Having selected one of these fields, the prospective fishery expert will not dissipate his efforts on various courses in any of the other three fields, but will center his undergraduate studies on one par-

ticular field. He will of course select that group of subjects which he will most need later on. Upon graduation he will be well trained in that field, be it administration or biology or economics or technology. By so doing he should be equipped to seek positions in the fisheries or other fields requiring a high degree of training in biology or technology or economics. This is basic training, the lack of which so often has greatly restricted the graduate from achieving the success to which he aspired and clouded the apparent usefulness of the institution of learning. Our student is now either a biologist, an economist or a technologist or prepared to enter the field of commerce and administration. He certainly is not a jack-of-all-trades, lacking specialized training in any field. If unable to take post-graduate work he is prepared to give a good account of himself in his chosen field.

If in his undergraduate days our student planned to enter the fishery field, he will have chosen his undergraduate studies with that end in view and after graduation, if practical, he will major in his chosen field, conducting independent research which will give him practical training and demonstrate his capabilities as a research worker.

### Biology

If our student chooses fisheries biology, he should select courses fitting him for specialization in one of a number of fields such as aquiculture (including fish culture), fisheries science, oceanography, pollution, physiology or some other such field. He will have taken fundamental courses in biology, physiology, etc., and special courses to qualify him for his particular field. For example, if he proposes to specialize in fisheries science he will not neglect his mathematics and statistical practices. There should be open to him on completion of his studies biological positions in federal and state governments, in private employ, etc. There are over four hundred federal and state hatcheries, and the number is growing. In time each of these should be headed by men with a good grounding in biology. The day is at hand when the water farmer—oyster, goldfish, trout, terrapin, clam—will need a biologist to help raise his standard of production and overcome the many difficulties encountered. These are but a few of the many possibilities.

### Economics

In case our student specializes in fishery economics, he has open to him federal and state positions. In my opinion, the man who made the greatest contribution to fisheries science in 1929 was an economist who unfortunately will receive very little personal credit for the culmination of some five years of specialization. I refer to the chief fishery investigator of the U. S. Tariff Commission, who probably has no superior in fishery economics in the country. There are various other positions in this group in the more specialized fields of fishery statistics, marketing, world trade, etc. Not only that but large business enterprises are rapidly taking on economists to help them meet successfully the very keen competition for world markets. The principal reason for there being so few in the fisheries field is the lack of trained fishery economists capable of demonstrating their value to industry.

### Technology

Here as in the biological field our student would do well to determine what particular branch of fisheries technology he expects to follow. He may specialize in chemistry, engineering, canning, etc. The first fishery products laboratory in this country was established in Washington, D. C., in 1918, and the first college of fisheries at the University of Washington, Seattle, in the same year. These institutions have contributed greatly in making the fisheries technologically minded, as well as serving as training schools for graduating into industry men who have assumed positions of leadership in their professions. The rapidity with which well-trained men have been snapped up demonstrates adequately the need for training additional men for this field, which holds forth opportunities for financial reward as great as any in the fisheries field except possibly the following group.

### Administrators

As in other lines of administration and commerce, there is room for highly trained executives in the fisheries field. In industry these men can well follow the usual business courses, including business organization—business law, marketing, principles of advertising, exporting, importing, employment, organization and management, statistics, credits and collections, salesmanship, sales management, etc.; geography—world trade, industries, trade centers, trade routes, geography and history of commerce, etc.; economics, cost accounting, etc. This group is more closely affiliated with economics than with either of the other groups.

In addition to the business executives, there should be many openings in state governments. Our heads of departments of conservation should be taken out of politics and replaced by capable and well-trained administrators with a full appreciation of the importance of biology, economics and law enforcement procedure.

At the beginning of this acticle, I divided our fishery personnel into three groups. In succeeding pages, I have discussed primarily the training required by the key men. Those of good education who fall short of finding a place in the first group will automatically gravitate to the second. What I have attempted to emphasize is the need for specialized training and the avoidance of taking a hodgepodge series of subjects in biology, technology, economics, navigation and snap courses which give credits toward graduation but may lead to the dismal swamp of failure after graduation. Perhaps that is a bit overdrawn, for any training in the fishery field promises to be better than no training at all. In fact, the science of agriculture has passed through various transition stages to its high state of perfection of to-day reflected in the names of many of the bureaus in the U. S. Department of Agriculture, *viz.*, Bureaus of Agricultural Economics, Animal Industry, Dairy Industry, Plant Industry, Chemistry and Soils, Entomology, Home Economics, etc. Of the four fisheries fields referred to, there is the greatest need to-day for trained men in economics and administration, men who will demonstrate the importance of such training to the industry.

Any university desiring to give special attention to training men for the fisheries and already having strong departments of biology, economics, technology and administration should have a well-trained economist and administrator familiar with the fisheries and the opportunities which the fisheries field has to offer as a head of the fisheries group. During the four years of undergraduate work, students intending to specialize in fisheries, in whatever field, might be given a one-hour weekly lecture course by this man to bring them together as a unit and familiarize them with the fisheries field. Lecture courses would include domestic fisheries, world fisheries, importance of fisheries and fishery products, methods of preservation and utilization, costs of production (rudimentary), competitive situation, exports and imports and other basic training needed for a proper understanding of the fishery situation. Under this plan the fishery head could carry the principal burden of training and directing fisheries men into proper fields. Such a plan would not require an extensive fishery organization but would have the advantage of training men for all branches of the fisheries. There is no adequate plan of this character in existence in the United States to-day.

LEWIS RADCLIFFE,
*Deputy Commissioner of Fisheries*
BUREAU OF FISHERIES

## SUPPORT OF THE ZOOLOGICAL RECORD

VOLUME 66 of the *Zoological Record* contains the announcement that "Volume 67, dealing with the literature of 1930, is in preparation and will be printed and published if a sufficient support is obtained." The *Zoological Record* is accepted in this country too much as a matter of course. Not enough thought is given to the great amount of work required to prepare it, the contribution of the Imperial Institute of Entomology, nor to the financial burden of publishing it largely borne by the Zoological Society of London.

The *Zoological Record* is a necessity wherever taxonomic work is done, but it has never received due support from American institutions, where now in the aggregate it must be put to more use than in any other country in the world. American institutions should realize that subscriptions (in our sense) do not support the *Record;* in fact they do not bring back a fourth of the outlay on each volume. The remainder of the cost must be made up by contributions, and the Zoological Society of London should not be expected to carry the whole load. For Volume 65 the contribution of that society exceeded five times those from all other sources combined.

The situation is manifestly unfair, as the work is an altruistic one serving the needs of systematists everywhere. There is no substitute for the *Zoological Record,* and if its publication were suspended, American institutions would find it necessary at once to produce such a publication themselves. This can be avoided by giving merited support to the present going publication. Every American museum and every American society or institution having workers doing systematic work should feel under obligation to contribute to the *Zoological Record.* Directors of museums and treasurers of societies should put an item for this purpose in their annual budgets so that it shall not be left to chance, or perhaps come up for consideration when no funds are available. Contributions should be sent to the Secretary, Zoological Society of London, Regent's Park, London, N. W. 8, England.

The report of the society for 1929 contains a statement on contributions to the *Record* and it is not one to make an American feel proud. A few individuals and societies have done nobly, but museums in general have simply shirked. There is an obligation for support upon those who use the *Zoological Record,* and it is to be hoped it will be taken much more seriously by American institutions in the future than it has been in the past.

W. L. MCATEE
WASHINGTON, D. C.

# QUOTATIONS

## A GREAT ASTRONOMER

PROFESSOR TURNER, whose death at the age of sixty-nine is announced on another page, was not only a pioneer in astronomical research, but was also a singularly gifted expositor of the wonders of his science. In him *The Times* loses a valued contributor of long standing.

Herbert Hall Turner, the son of Mr. John Turner, was born at Leeds in 1861, and was educated at Leeds Modern School, Clifton College, and Trinity College, Cambridge. His career at Cambridge was brilliant; he graduated as second wrangler in 1882, and was second Smith's prizeman in the following year. He was elected a fellow of Trinity, but left Cambridge in 1884 to become chief assistant at the Royal Observatory, Greenwich, where he remained until 1893, when he was appointed to succeed Professor Pritchard as Savilian Professor of Astronomy and director of the University Observatory at Oxford.

Turner's contributions to astronomy were remarkable for their number and variety; he published over two hundred papers and essays on scientific subjects. He had a fertile and ingenious mind, and more than the usual amount of courage in putting forward ideas and speculations. Many of his ideas have not met with general acceptance, but this is a fate that must befall some part of the work of any one who has a claim to be called a pioneer. When he assumed the direction of the University Observatory at Oxford, he found it committed to taking a part in the international scheme of mapping the heavens, which had been decided upon at a conference in Paris in 1887, and he threw himself into the work with so much enthusiasm that the Oxford section was finished before that of any other observatory with the exception of Greenwich, the only other observatory in England which was allotted a part in the scheme. He then proceeded to help some of the other observatories which were finding the burden of the work too heavy for them, and when the International Astronomical Union was formed after the war, he was elected president of the committee delegated to deal with the scheme.

Much of the technique of the methods now universally employed for deriving the positions of stars from photographs is due to him, and this is perhaps his greatest contribution to astronomy. He also did a large amount of useful work on the classification of variable stars, and put forward a theory to explain stationary meteor radiants, but his explanation of sunspots as being due to a swarm of meteors formed by collision between the Leonids and the rings of Saturn has not been generally accepted, and the same must be said of his attempt to account for the two star streams in terms of gravitation.

When Professor Milne, the seismologist, died in 1913, Professor Turner took over the control of his seismological bureau at Shide, and on the return a few years later of Mrs. Milne to Japan the bureau was moved to Oxford, where it remained under the direction of Professor Turner as president of the seismological committee of the British Association. He was also president of the seismological section of the International Geophysical Union, and himself did a large amount of work on the analysis of earthquake records, with a view to detecting periodicities in them. His frequent communications to *The Times* on earthquakes he had detected in remote parts of the world will be well remembered, as also his letters and articles on eclipses and other astronomical subjects.

He spared no effort to promote international cooperation in astronomy, and was a well known and popular figure at international conferences, of which he attended a large number. He also went on several eclipse expeditions, including those to Japan in 1896 and to Egypt in 1905, and when the office of foreign secretary of the Royal Astronomical Society fell vacant in 1919, he was clearly marked out for it.

Turner had a great gift for presenting the complicated facts of modern astronomy in a way easily understood by the lay mind, and was an excellent lecturer. He wrote four very readable popular books on astronomy, "Modern Astronomy," "Astronomical Discovery," "The Great Star Map" and "A Voyage in Space," the last being the outcome of a series of children's lectures at the Royal Institution in 1913. For more than thirty years he contributed each month to the periodical, the *Observatory,* a series of notes, light in vein, under the heading "From an Oxford Note Book," which formed a feature of the magazine that has been greatly appreciated by astronomers all over the world. He was for many years secretary, and then president, of the Royal Astronomical Society Club, where he could always be counted upon for an apt after-dinner speech, and, on occasions of any importance, for a song. He had the all too rare gift of being able to enter into other people's difficulties, and there must be many amateur astronomers, in addition to some of the younger professional astronomers, who will always gratefully remember help and advice given both frequently and ungrudgingly.

As Savilian Professor at Oxford, Turner became a fellow of New College. Coming to the university, he

threw himself wholeheartedly into the intimate life of the college, entering with zest into its activities, educational, scientific and social, and contributing a valuable element to its discussions by his independent, yet sympathetic, point of view and a breezy disregard of conventions which now and again shocked more conservative minds.

It was unfortunate that the refusal of the university to provide an official house in the Parks for the Professor of Astronomy made his relations with the university less cordial. This and the remoteness of astronomical studies from the ordinary curriculum rendered his influence in Oxford less than it ought to have been. But those who knew him well were aware of the keen interest which he took in its studies and general welfare, and also in the lives of his friends and colleagues. No one was more ready to give active help to his friends in any time of trouble. It was characteristic of his generous temper and his sympathy with struggling causes that from the first he gave his vigorous support to the Workers' Educational Association and the organization of tutorial classes. In this work his optimism and persistence were invaluable.

Here, as in everything else he took up, his help was direct and personal. He had the courage and strong will of a true Yorkshireman, and he also shared the North Country love of music; he was an assiduous member of the Oxford Bach Choir, and an active supporter of musical enterprises. A lover of the open air, he had a close acquaintance, by bicycling, boating and walking, with the beautiful country near Oxford, and in other parts of England, and his scientific expeditions gave him a wide acquaintance with the oversea dominions and with foreign countries. In these activities he was fortunate in having a wife who shared in his tastes and in much of his travel. The astronomical world is weaker by his death, and he has certainly left in his college and among his friends in the university a place which can not be filled.

Professor Turner was elected a fellow of the Royal Society in 1896, and was president of the Royal Astronomical Society in 1903 and 1904. From 1913 to 1922 he was one of the general secretaries of the British Association. He was given the honorary degree of D.Sc. by the Universities of Leeds, Sydney, Wales and Strasbourg, that of D.C.L. by Durham, and that of LL.D. by California. He was also a corresponding member of the French Institute, and he received the Bruce gold medal of the Astronomical Society of the Pacific in 1927.—*The London Times.*

# SCIENTIFIC APPARATUS AND LABORATORY METHODS

## AN IMPROVED METHOD FOR THE STUDY OF NUTRITIONAL ANEMIA IN THE WHITE RAT

RAPID progress in solving the mysteries surrounding the underlying causes of pernicious anemia has been made within the past four years.[1] One of the phases of this problem which has attracted the attention of many investigators is the study of nutritional anemia in the white rat.

Young rats at the weaning age become anemic when fed 4 to 6 weeks on whole milk only, for at this stage the store of iron in the body is at a low ebb. It has been noted in some instances, however, that anemia did not appear unless milk was fed over a prolonged period or even to the second generation.[2] The authors were surprised to find that under the conditions in their laboratory a number of rats fed whole milk only or whole milk plus cod-liver oil grew well and for the most part were about normal in hemoglobin content (Fig. 1). Studies were therefore conducted to learn why the conditions under which these animals were kept were not conducive to anemia.

[1] SCIENCE, 71, (No. 1850): x, June 13, 1930.
[2] W. M. Happ, *Bul. Johns Hopkins Hosp.*, 33: 163, 1922.

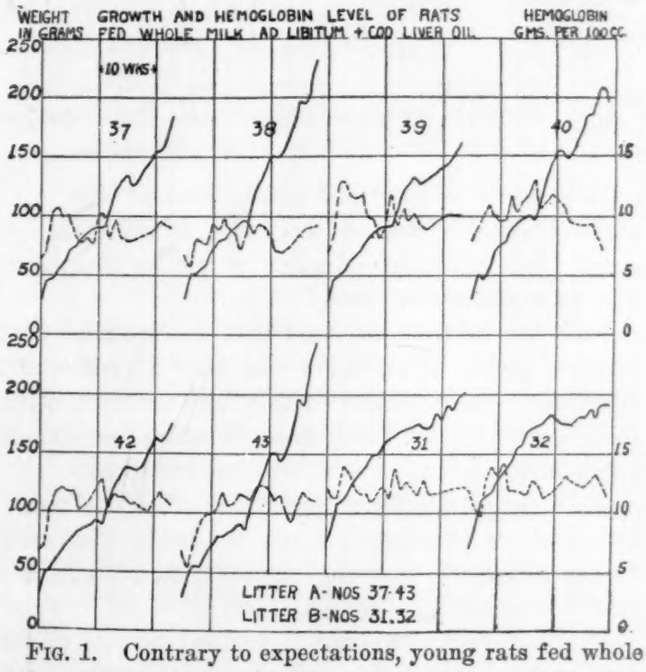


FIG. 1. Contrary to expectations, young rats fed whole milk and cod-liver oil made good growth and in most cases were normal in hemoglobin content. The solid curves show live weight and the broken lines the amounts of hemoglobin in the blood.

The cages employed in the early work were constructed of galvanized iron wire, having a mesh small

enough to retain most of the feces. There were places on the cages where the zinc had been worn off. The rats were observed to gnaw these wires vigorously.

Questions were therefore raised regarding the effect upon hemoglobin formation of several factors, including the material of which the cage was composed, the access of the rat to fecal material, the feeding of cod-liver oil, and others.

Cages of different material were therefore constructed. In these the wires or rods forming the bottoms were spaced one half inch or more apart to prevent retention of feces in the cage. Later all cages were equipped with legs to prevent the animals from reaching shavings or feces below the cages. Paired feeding trials carried out with animals kept in cages of different materials showed that the low hemoglobin values of young rats at the weaning stage rose quickly to normal when the animals were placed in iron wire cages and remained at high levels (Fig. 2). The ani-

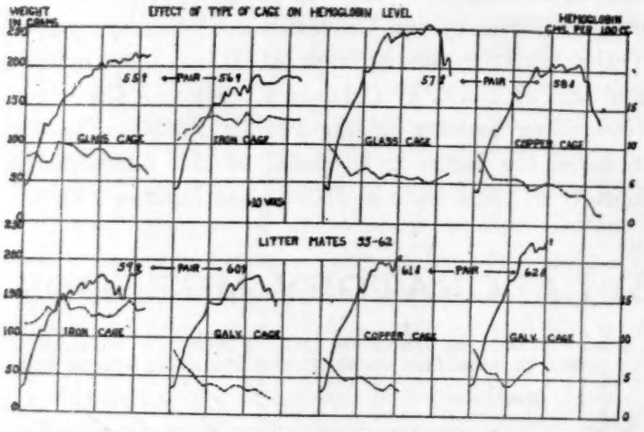


FIG. 2. Rats can secure enough minerals from cages in which iron wire is exposed to prevent anemia.

mals in glass, copper and well-galvanized iron wire cages gradually became anemic. Some cures of anemic rats have been effected by placing them in a cage of common iron wire.

With the evidence at hand that the material used in construction of the cages may have a pronounced effect upon the condition of rats kept in them, other factors were studied, using cages in which the animals could come in contact with nothing but glass.

Cod-liver oil was found to have no effect, the hemoglobin values of young animals fed fresh whole milk and cod-liver oil declining rapidly. This result has also been noted by Krauss.[3]

The literature is lacking in detailed reports of the feeding methods used in different laboratories. Apparently animals are fed once daily in some cases, twice daily in others and in one instance once daily six days per week. The effect upon hemoglobin titer of the amounts of milk consumed was studied (Fig. 3). Lot 1 was fed milk once daily six days per week.

[3] W. E. Krauss, *Jour. Dairy Sci.*, 12: 438, 1929.

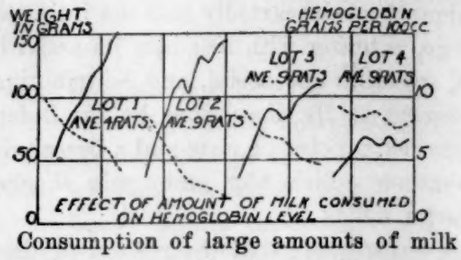
WEIGHT IN GRAMS
HEMOGLOBIN GRAMS PER 100 CC
LOT 3 AVE. 9 RATS
LOT 4 AVE. 9 RATS
LOT 1 AVE. 4 RATS
LOT 2 AVE. 9 RATS
EFFECT OF AMOUNT OF MILK CONSUMED ON HEMOGLOBIN LEVEL

FIG. 3. Consumption of large amounts of milk induces anemia more quickly than small amounts.

Growth was rapid and hemoglobin values declined less rapidly than in Lot 2, which was fed milk ad libitum twice daily seven days per week. Lots 3 and 4 were fed in the same manner as Lot 2, except that they received only three fourths and one half, respectively, the amount consumed by Lot 2.

Carefully controlled paired feeding trials in which the control animal was fed milk twice daily ad libitum, and its mate three fourths the amount, also showed that the hemoglobin values in the animals fed the smaller amount declined less rapidly.

As already noted, the galvanized wire cages used in the first trials had a mesh of such size that many of the feces were retained in the cages. The effect of the presence of feces in the cages was studied in paired feeding trials in which the animals were kept in specially constructed glass cages. The bottom of the cage for the control animal consisted of glass rods spaced about one half inch apart, while in the cage of the pair mate the glass rods were close enough together to retain the feces. The hemoglobin values of all animals declined rapidly, but those of the animals having access to feces declined somewhat less rapidly (Fig. 4). A more efficient utilization of food by rats

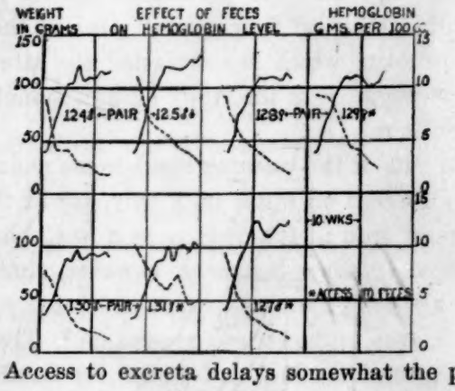


FIG. 4. Access to excreta delays somewhat the progress of anemia.

having access to excreta and shavings was noted by Griffith.[4]

In view of these findings, a special laboratory technique for the study of nutritional anemia has been developed.

The cages are constructed of wood and glass in such a way that the animals can come in contact with noth-

[4] W. H. Griffith, *Jour. Biol. Chem.*, 85: 751, 1930.

ing but glass. Tops and bottoms consist of glass rods spaced about one half inch apart. The top is removable. Sides are lined with window glass. The floor space allowed each animal is about 10 x 14 inches. Cages are mounted on legs about 4 inches high. Galvanized iron pans 2 inches deep and containing wood

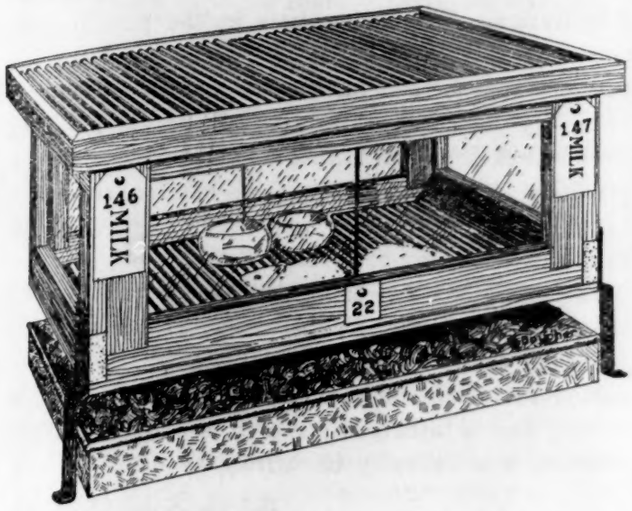


FIG. 5. Two-compartment glass cage designed for the study of nutritional anemia.

shavings fit loosely below the cages to receive the excreta. Shavings are changed twice weekly. Cages are washed once weekly, a washing powder solution being used, followed by rinsing with tap water, then distilled water, and drying with a clean towel.

Glass sponge dishes (common office type) are used as feed dishes. These are practically non-spillable, easily washed and not readily broken. These are washed twice daily, using a stiff brush with washing powder solution. They are rinsed in tap water, drained on a drying rack made of glass rods, then rinsed in water redistilled from glass, and again drained.

The whole milk used is obtained by milking the cow directly into a glass funnel and glass jug. It is placed in a refrigerator shortly after milking. A fresh supply is obtained daily.

Hemoglobin determinations are made every two weeks, using a colorimeter with Newcomer hemoglobin attachment. This is checked for accuracy by means of the Van Slyke oxygen capacity method.

The plan of feeding animals in pairs is employed in most cases. In this plan two litter mates of the same sex and weight constitute a pair. Milk is fed twice daily, the amounts fed being adjusted so that the amounts eaten by both animals are the same. The specially treated milk or special experimental routine is given one animal, the other constituting a control or check animal. Differences in food intake, which often greatly complicate the interpretation of results, are thus avoided. It is possible in this way to attribute differences in growth and hemoglobin levels to the experimental condition under investigation.

### SUMMARY AND CONCLUSIONS

Experiments in our laboratory have demonstrated that white rats fed only fresh whole milk secured enough minerals from their cages to prevent anemia.

Animals consuming large amounts of milk became anemic more quickly than those limited to small amounts.

Access to feces delayed somewhat the onset of anemia.

These results probably explain some of the conflicting data reported in the literature and also raise a question regarding the correctness of conclusions drawn from experiments in which recognition was not given the factors shown in this study to be important.

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## SOME NEW METHODS AND COMBINATIONS IN PLANT MICROTECHNIQUE

IT is a common experience to find beginning students in plant histology failing to secure good sections of ordinary or thin leaves embedded in paraffin, because of serious plasmolysis or imperfect infiltration.

It occurred to the writer that the glycerine process used in the Venetian turpentine method for extremely delicate tissues such as algae might be adapted to the paraffin method to assure dehydration without plasmolysis. This year, the following method has been tried with excellent results even by students that are below average.

In the case of leaves that have been killed in an aqueous solution, the material is first thoroughly washed, then put into 10 pts. glycerine + 90 pts. water, in a flat open dish, and left until the solution becomes about as thick as pure glycerine. It is then washed in 95 ethyl alcohol and put through two changes of absolute ethyl alcohol, followed by: absolute alcohol 3 pts. xylol 1 pt.; absolute alcohol 1 pt. xylol 1 pt.; absolute alcohol 1 pt. xylol 2 pts.; pure xylol. It is then embedded in paraffin in the usual way.

Leaves that have been killed in an alcoholic solution, however, after being washed in a similar concentration of alcohol, are put into a solution of glycerine mixed with a water percentage equal to the alcohol percentage of the killing solution. For instance, material killed in a 50 alcohol-acetic acid-formalin solution is first put into equal parts of glycerine and water. With this exception, the method is the same as that used following an aqueous killing solution.

In every case, leaf material prepared in this way is less brittle and cuts much more easily than after the usual treatment (perhaps because it is in alcohol a shorter time), and even when embedded by more or less careless students shows little or no plasmolysis. This method also requires less attention.

The following modification of the method for "dehydrating woody tissue for paraffin embedding" as given in SCIENCE for January 24, 1930, has been used successfully.

After the killing and fixing solution has been washed out, if the material is soft enough to cut easily, it is placed in 10 pts. glycerine + 90 pts. water and left until the water has evaporated. It is then put into equal parts glycerine and butyl alcohol for about 36 hours, followed by pure butyl alcohol for another 36 hours. It is then embedded as described in the article in SCIENCE. Three to six days in the paraffin bath may be necessary to secure thorough embedding.

If tissues are part hard and part soft, they may be softened in C.P. hydrofluoric acid + 95 alcohol, as this method, according to Dr. E. C. Jeffrey, injures delicate tissues less than hydrofluoric acid diluted with water. If tissues are very hard, they may be put into C.P. hydrofluoric acid for three or four weeks, then washed and treated as described.

This method has the advantage of practically avoiding the use of ethyl alcohol, with the result that the material is less brittle and no harder than before dehydration. The longer time in the paraffin bath does not appear to make woody tissues hard and brittle. This method likewise requires less attention.

In dry weather or in dry climates it has been found that the addition of eight or ten parts of glycerine to preservatives such as alcohol-acetic acid-formalin is efficacious in preventing rapid evaporation caused by imperfect cork stoppers.

In cutting wood sections that are likely to curl, if the microtome knife is kept wet with equal parts of glycerine and 95 alcohol, and each section is permitted to remain on the blade a few seconds after cutting and is then transferred to a dish of the same solution, this difficulty is entirely avoided.

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# SPECIAL ARTICLES

## DATA ON A PROTEIN-ANTIBODY SYSTEM

IT was recently shown by the writers that the entire course of the precipitin reaction between Type III pneumococcus specific polysaccharide and purified homologous antibody could be expressed quantitatively by simple equations that follow the mass law.[1] Since it was of interest to determine whether a similar method of treatment might be applied to a true antigen-antibody system, recourse was had to the compound azo proteins, so fruitfully employed in the solution of other immunochemical problems by Landsteiner and by Avery and Goebel. It was felt that if a protein dye could be synthesized of more intense color and more rigorously freed from its component substances than those used by these workers, a possible means would be at hand for distinguishing between antigen and antibody nitrogen both in the precipitates and supernatants, since the antigen could be determined colorimetrically. A purplish-red disazo protein dye, *R-salt-azo-benzidine-azo-egg albumin,* was finally isolated in a form which satisfied these requirements, the more so as the antibody solutions obtained by sodium sulfate fractionation of rabbit antisera to the dye were substantially colorless.

By methods analogous to those used in the first paper[1] it was found that at the lowest concentration of dye protein used, 1:67000, the mean ratio between antigen and antibody precipitated was 1:15 (8 determinations); at the equilibrium point,[1] at which the proportions of the reactants were such that both antigen and antibody were present in solution, 1:7.5 (6 determinations), and in the inhibition zone, after the maximum precipitate was reached, 1:3 (14 determinations).

These preliminary data indicate that the composition of the solid phases formed by the precipitin reaction between the dye and its antibody may be expressed by the three limiting equations:

$$\mathrm{An} + \mathrm{Ab} \rightleftarrows \mathrm{AnAb},$$
$$\mathrm{AnAb} + \mathrm{An} \rightleftarrows \mathrm{An_2Ab}, \text{ and}$$
$$\mathrm{An_2Ab} + 3\mathrm{An} \rightleftarrows \mathrm{An_5Ab},$$

in which An = antigen and Ab = antibody. The data so far obtained are insufficient for a decision as to whether the soluble compound formed in the inhibition zone is $\mathrm{An_6Ab}$ or $\mathrm{An_7Ab}$. Further work is in progress and a detailed report will be made when this has been carried out.

Whether or not modification of the above ratios be necessary, it would appear that the precipitin reaction between a true antigen and its antibody is essentially the same as the precipitin reaction in a hapten-antibody system or, for that matter, essentially the same as a typical inorganic precipitation reaction, and may

[1] *Jour. Exp. Med.*, 50: 809, 1929.

be quantitatively expressed by suitable application of the laws of classical chemistry.[2]

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## THE AMOUNT OF CIRCULATING PRECIPITIN FOLLOWING THE INJECTION OF A SOLUBLE ANTIGEN

IN the preceding note preliminary data were reported on the precipitin reaction between a protein and its homologous antibody. These data permit for the first time a calculation of some theoretical interest; namely, the amount (weight as opposed to titer) of circulating precipitin in an animal following immunization by a given amount of antigen. For example, rabbits 49 and 54 were injected with small doses of *R-salt-azo-benzidine-azo-egg albumin* until a total of 21.6 mg of the dye had been given. The animals were bled 10 days after the last injection, and antibody solutions were prepared by sodium sulfate fractionation and made up to double the serum volume. This may be considered as blood volume for the present purpose. The maximum specifically precipitable protein[1] in solution 49 was 1.53 mg per cc; in solution 54, 1.25 mg per cc. Taking the weight of the rabbits as 2 kg and their blood volume as 5.5 per cent. of their weight,[2] or 110 cc, the blood of rabbit 49 contained 168 mg of precipitin at the time of bleeding, while that of rabbit 54 contained 138 mg. Calculated as milligrams of circulating precipitin per milligram of antigen injected, the values are 7.8 and 6.4, respectively.

Naturally these figures are inaccurate, since the exact blood volumes of the rabbits were not known. From the theoretical standpoint, however, it is of interest that they are probably low, since losses undoubtedly occurred in the preparation of the antibody solutions. Moreover, these values can only represent a fraction of the total antibody formed, since storage in the cells occurs as a result of sensitization of tissues and organs. It is also not certain that the circulating precipitin is the only circulating antibody. On the other hand it is considered, as in the preceding studies, that antibody is modified globulin, and that the antibody precipitated is not contaminated with nonspecific serum globulins. Evidence on the latter point will be reported later.

According to Svedberg and Sjögren[3] the molecular weight of serum globulin is three times that of egg albumin. If one assumes antibodies to have about the same molecular weight as the globulins with which they are associated, and the egg albumin dye to have about the same molecular weight as egg albumin, each dye molecule would have to split into more than two specifically reactive fragments if it participated in the building up of the antibody molecule. However, Landsteiner has repeatedly shown that the specificity of the azo protein dyes is a function of the dye component, rather than of the protein used. It would therefore be reasonable to expect that if the antigen or any of its fragments participated in the building up of the antibody molecule the antibody would be colored. It is true that the crude antibody solutions obtained by fractionation of the sera of animals immunized to the red protein dye were definitely pink, but the color disappeared almost completely on dialysis.

The preliminary data herein presented therefore tend to favor the view that the antigen itself does not participate in the building up of the antibody complex. Further information on this and related questions is being sought along these lines and it is hoped that more decisive figures will be obtained.[4]

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## CORRELATION OF ANTILLEAN FOSSIL FLORAS

CERTAIN Antillean plant beds have been described by Drs. Hollick,[1] Vaughan and Berry,[2] Hodge,[3] Howe[4] and Maury,[5] and a tentative grouping and correlation is now suggested.

*The Nilssonia bed, Porto Rico.*—South of Cidra, Mr. Hodge found plants in a bog iron ore bed.

[2] This study was carried out under the Harkness Research Fund of the Presbyterian Hospital.

[1] *Jour. Exp. Med.*, 50: 809, 1929.

[2] Meek and Gasser, *Am. Jour. Physiol.*, 47: 302, 1918–19.

[3] *Journ. Am. Chem. Soc.*, 50: 3318, 1928; 52: 2855, 1930.

[4] This study was carried out under the Harkness Research Fund of the Presbyterian Hospital.

[1] "Rio Collazo Plant Beds, Porto Rico," "Scientific Survey of Porto Rico and the Virgin Islands," Vol. 7, pt. 3, 1928; "Siparia Flora, Trinidad," *Bull. N. Y. Bot. Garden*, vol. 12, No. 45, 1924; "Rio Guajataca Flora, Porto Rico," *Jour. N. Y. Bot. Garden*, 27: 223–7, 1926.

[2] "Sánchez Flora, Dominican Republic," "Geological Reconnaissance of the Dominican Republic," p. 165, 1921.

[3] "Algae of Coamo Springs Limestone, Porto Rico," "Scientific Survey of Porto Rico," vol. 1, pt. 2, pp. 153–9, figs. 15, 16 (not 18), pp. 195, 228, 1920.

[4] "Algal Flora, St. Bartholomew, Antigua, Anguilla," Carneg. Inst. Wash., Pub. No. 291, pp. 11–19, 6 plates, 1919.

[5] "Los Quemados Flora, Dominican Republic," *Bull. Amer. Paleontology*, No. 30, p. 19, 1917.

These were identified by Drs. Berry and Knowlton as *Nilssonia,* an old Mesozoic cycad genus; a species of the fern *Protorhipis,* and a dicotyledon. Drs. Britton and Hollick, in 1926, 1927 and 1928, examined this locality but found only unidentifiable plant fragments.

The *Nilssonia* flora lay beneath a horizon with corals referred by Mr. Hodge to *Cladophyllia furcifera,* suggesting an age corresponding to the Fredericksburg group of the Lower Cretaceous of the gulf states. But the foraminiferal evidence of the Rio de la Plata series said to underlie the Baranquitas-Cayey series (of which the *Nilssonia* bed is a member), as identified by Dr. Bagg, suggests an Upper Cretaceous age. This contradiction requires clearing up. Meantime the possibility of a Fredericksburgian age for the *Nilssonia* bed is very intriguing because of the practical absence of fossils of Lower Cretaceous age in the Dominican Republic and Haiti, and elsewhere than Cidra in Porto Rico, and even there the evidence is not certainly proved. Further studies may prove the *Nilssonia* bed to be Upper Cretaceous.

*The Archaeolithothamnium Antillean beds.*—Fossil calcareous algae are abundant in certain deposits on St. Bartholomew, Antigua, Anguilla and Porto Rico. *Archaeolithothamnium affine* Howe was described by Dr. Howe from the Antiguan Oligocene, and was compared to *A. turonicum* from the Turonian stage of the Upper Cretaceous of France. The *Archaeolithothamnium* found by Mr. Hodge in the Coamo Springs algal limestone, Porto Rico, shows affinities with both the Oligocene *A. affine,* and with the Upper Cretaceous *A. turonicum,* hence its stratigraphic position can not be set by this alga alone. Dr. Coryell has reported *Archaeolithothamnium* also in limestones on the Coamo-Aibonito road, Porto Rico.

*Flora of the Rio Collazo shales, Porto Rico.*—This flora was found by Dr. Hollick to be very rich in dicotyledons, with palms abundant, but only two cycads were present, one fern and one alga. Dr. Hollick noted its typical New World facies, tropical character and Tertiary age.

From the molluscan evidence I refer the Rio Collazo flora to the Antiguan Oligocene.

*The Siparia flora, Trinidad.*—This flora was described by Dr. Hollick in 1924, but no age assigned. My own paleontological studies in Trinidad lead me to regard the Siparia flora as of Miocene age. But its exact position in that period is not determined.

*The Los Quemados flora, Dominican Republic.*—In 1916, the Maury Expedition collected *Eugenia, Nectandra, Inga* and various species of woods from the Gurabo formation on Rio Gurabo, near Los Quemados. This flora was shown by molluscan evidence to be of Middle Miocene age. An arm of the sea with rich molluscan and coral life occupied the present valley of Rio Yaque del Norte, while the neighboring shores were bordered with myrtles, laurels, mimosas and a variety of forest trees.

*The Sánchez flora, Dominican Republic.*—In 1921, the Vaughan Expedition obtained plants from the clays near Sánchez in the northeastern part of the Dominican Republic. This flora apparently is later than that of Los Quemados, but its exact horizon has not yet been determined. Dr. Vaughan referred it to Miocene or Pliocene.

*The Rio Guajataca flora, Porto Rico.*—A Post-Pliocene walnut was described by Dr. Hollick from the valley of Rio Guajataca, in 1926, and named *Juglans archaeoantillana.*

*Antillean climates of the past.*—Antillean fossil floras indicate that the West Indian climate has remained unchanged from Antiguan Oligocene time to the present day.

Antillean sea shells in Tertiary time were also tropical in character, for their living allies are inhabitants of warm seas. In a very few instances, however, competition has forced their modern descendants to the deep sea where they live in almost freezing water. For example, the modern analogue of *Crepitacella melanoides* Gabb of the Dominican Middle Miocene is *C. gabbi* Dall, living in ooze at 785 fathoms. With rare exceptions, the shells like the plants indicate that the temperature of the sea and of the air was similar to that of to-day in the Antilles.

In connection with Antillean stratigraphy, in reply to Professor Meyerhoff's criticism[6] of my recent paper,[7] I would say that my statement was based on the fact recorded by Dr. Vaughan[8] that R. T. Hill collected Caprinidae *in limestones* near Fajardo, eastern Porto Rico, and at Cape San Juan which forms the northeastern extremity of the island. I would also like to add that the identification of *Venericardia alticosta* Conrad, from the Rio Jueyes Water Gap, Porto Rico, was made by Professor Grabau, and hence is highly authoritative.

A further note on the age of the Porto Rican Sirenian may be of interest to vertebrate paleontologists. In 1915, Dr. Reeds found a fossil Manatee in the shales at the ford on Jacaguas River, one kilometer northeast of Juana Diaz, southern Porto Rico. This was named *Halitherium antillense* by Dr. Matthew, in 1916, but its age remained indeterminate. The invertebrate fauna of the Juana Diaz shales proves the Manatee to have lived in Antiguan Oligocene time.

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[6] SCIENCE, 71: 322–3, March 21, 1930.
[7] SCIENCE, 70: 609, December 20, 1929.
[8] *Jour. Washington Acad. Science,* vol. 13, No. 14, 1923.